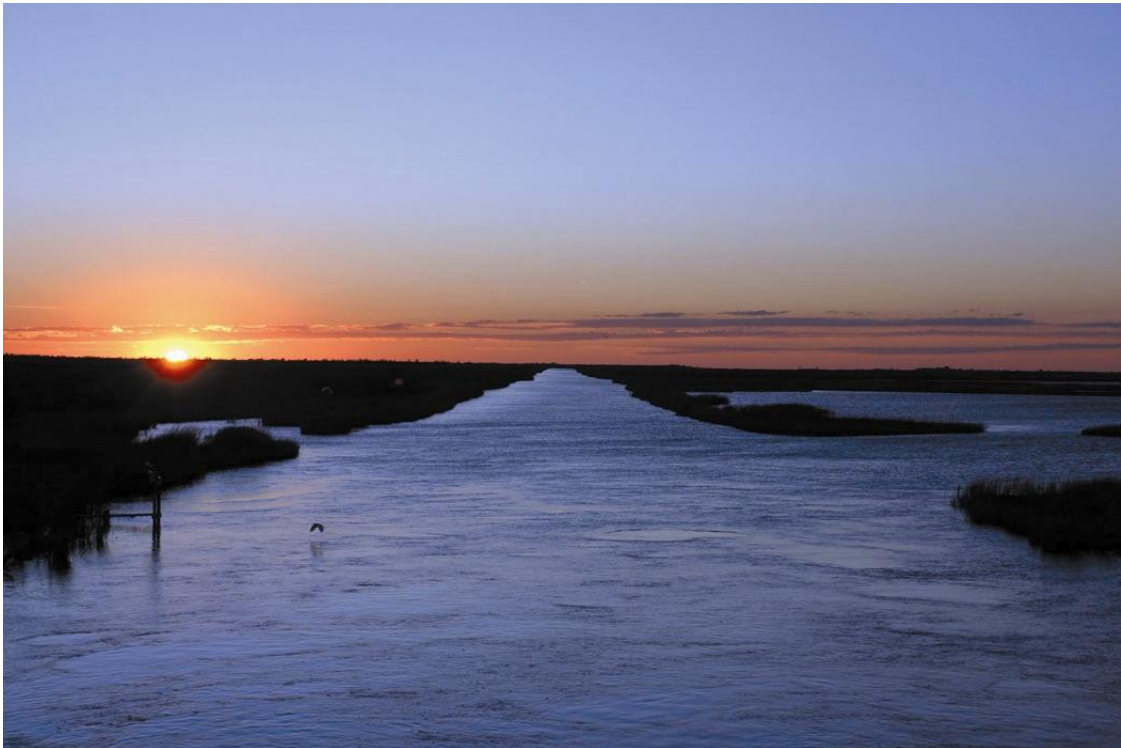


HABITAT MANAGEMENT PLAN FOR **SABINE NATIONAL WILDLIFE REFUGE**

Cameron Parish, Louisiana



Southeast Region



Sabine National Wildlife Refuge

Habitat Management Plan



**U.S. Department of the Interior
Fish and Wildlife Service
Southeast Region**

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Executive Summary

The 125,790-acre Sabine National Wildlife Refuge (NWR) is one of four refuges in the Southwest Louisiana National Wildlife Refuge Complex. Sabine NWR was set aside for the following purposes (USFWS 2007):

Executive Order 7764, dated December 6, 1937, stated the official purpose of the refuge: "...as a refuge and breeding ground for migratory birds and other wildlife." A secondary purpose of the refuge is "...for use as an inviolate sanctuary, or for any other management purpose, for migratory birds..." [16 U.S.C. 715d (Migratory Bird Conservation Act)].

The refuge protects saline, brackish, intermediate, and freshwater marshes and provides habitat for thousands of waterfowl and other wetland-adapted bird species as well as aquatic habitat for a rich and productive fishery. This Habitat Management Plan is a step-down plan which provides detailed habitat management goals, objectives, and strategies to conserve and protect the resources of concern for the next 15 years. This plan follows the refuge Comprehensive Conservation Plan (CCP, USFWS 2007), which provides an overview for all management actions on the refuge.

Refuge resources of concern were selected based on statutory requirements and information in the CCP regarding the highest priorities for refuge management. Resources of concern for Sabine NWR are:

- Waterfowl
- Marsh Birds
- Fisheries

The following goals and objectives reflecting the refuge purposes have been selected:

Goal 1—Maintain, restore, and enhance fresh, intermediate, and brackish coastal marsh habitats on Sabine NWR so that, as much as is possible, natural ecosystem processes operate to provide high-quality habitat for waterfowl, waterbirds, and fisheries, in quantities which meet or exceed the refuge's commitments under regional and national planning efforts and fulfill the purposes for which the refuge was created.

Objectives under this goal describe:

- Target conditions for impounded (oligohaline) marsh;
- Target conditions for unimpounded (brackish/saline) marsh; and
- Target acreages and locations for unimpounded marsh restoration through beneficial dredge spoil application.

Goal 2—On naturally occurring uplands in Sabine NWR, fire-sculpted native prairie and prairie-marsh ecotones will provide high-quality habitat for mottled ducks, prairie-dependent birds, and other native prairie species.

The objective under this goal describes:

- Target conditions for the native prairie islands on the refuge.

Goal 3—Contribute to the long-term protection and recovery of aquatic resources of concern on Sabine NWR and in the Gulf Coast ecosystem by integrating, in a manner consistent with the purposes of the refuge, habitat management, monitoring, and adaptive management principles to maintain and enhance healthy aquatic habitats on Sabine NWR.

The objective under this goal describes:

- Target conditions for oligohaline aquatic habitat on the refuge.

Strategies detailed in the plan reflect recent improvements in infrastructure on the refuge and incorporates an adaptive management approach. Principal management tools include hydrologic manipulation through water control structures, the application of prescribed fire and wildland fire use, construction of terraces, beneficial application of dredge spoil, and removal of exotic plants and animals.

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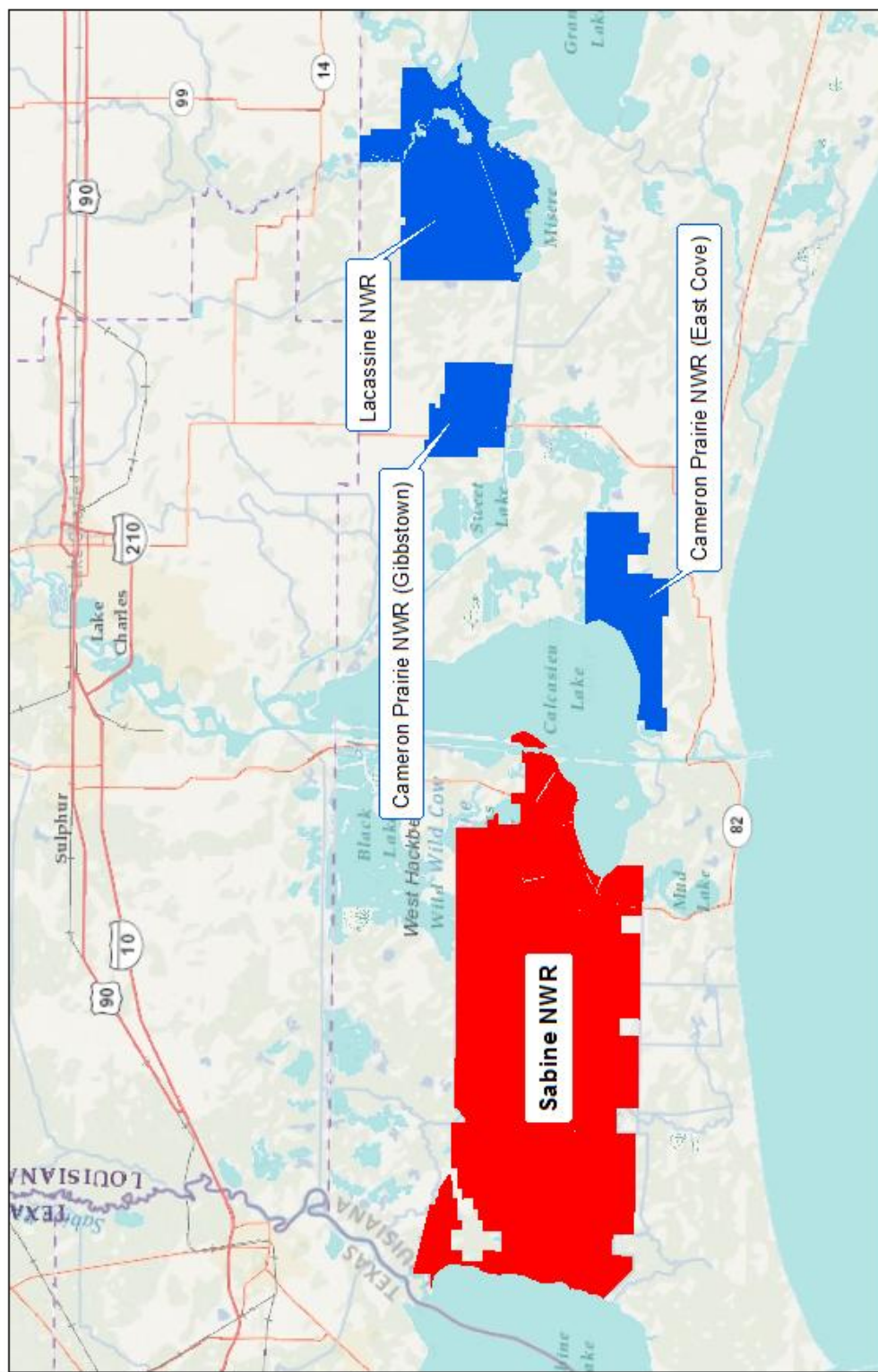
U.S. Fish and Wildlife Service. 2012. Sabine National Wildlife Refuge habitat management plan. U.S. Department of the Interior, Fish and Wildlife Service, Atlanta, Georgia, 165 pp.

I. Introduction

National wildlife refuges have been in existence for more than a century, and during that time they have played a crucial role in providing habitat for trust fish and wildlife species, as natural laboratories for the advancement of the science of wildlife management, and as places where the American public can go to hunt, fish, and learn about our nation's natural heritage. As the United States enters the second decade of the Twenty-first Century, the role of the Fish and Wildlife Service's National Wildlife Refuge System is becoming increasingly important. Threats on an unprecedented scale--global climate change, exotic invasive species, and unsustainable land uses--are causing irreversible changes to the natural systems on which we all depend. Properly managed conservation lands, scaled to the level of the threats they face, not only continue to serve their traditional purposes, but are also becoming increasingly essential to ensure the survival of natural systems and species, including our own. To meet these new challenges, managers will need to build adaptability and flexibility into land management plans. Adaptive management, "the rigorous application of management, research, and monitoring to gain information and experience necessary to assess and modify management activities" (602 FW 1) is not only Service policy, but increasingly, will be the only feasible option for successful management of Fish and Wildlife Service (Service) lands.

Sabine National Wildlife Refuge (NWR) covers 125,790 acres of marshland and open water in southwestern Cameron Parish, Louisiana (Figure 1), and is within the Service's Gulf Coast Prairie Landscape Conservation Cooperative (LCC). The Service manages land in southwest Louisiana through an approach called strategic habitat conservation (SHC). We consult with neighboring landowners, both private and public, on habitat management strategies to achieve long-term goals identified in various state and local planning documents, including comprehensive conservation plans for all the refuges in southwest Louisiana. Sabine NWR encompasses a range of marsh habitats from brackish to fresh. Historically, Sabine NWR has operated three impoundments which were constructed for the purpose of maintaining freshwater marsh habitat, and were managed to favor wetland plants beneficial to migratory waterfowl and other wetland wildlife. Recent storm impacts (hurricanes in 2005 and 2008) breached the levees and inundated freshwater marsh habitat within these impoundments with saltwater. At this writing (January 2012), the impoundments are kept open to tidal flow, although the levees have been repaired, and the stoplog structures in them are functional.


U.S. Fish & Wildlife Service
Southwest Louisiana National Wildlife Refuge Complex
 Sabine, Cameron Prairie, and Lacassine National Wildlife Refuges
Refuge Lands and Surrounding Area



A. SCOPE AND RATIONALE

This Habitat Management Plan (HMP) is a step-down management plan of the Comprehensive Conservation Plan for Sabine National Wildlife Refuge. The comprehensive conservation plan (CCP) describes the desired future conditions of a refuge or planning unit, and provides long-range guidance and management direction to achieve the purposes of a refuge. The CCP ensures that each refuge contributes to the National Wildlife Refuge System (Refuge System). The mission of the Refuge System is to provide a network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans. The CCP for Sabine NWR was completed in 2007 (U.S. Fish and Wildlife Service 2007).

An HMP is a dynamic working document that provides the refuge manager with a decision-making framework; guidance for the management of refuge habitats; and long-term vision, continuity, and consistency for habitat management on refuge lands. Each HMP incorporates the role of refuge habitat in international, national, regional, tribal, state, ecosystem, and refuge goals and objectives; guides analysis and selection of specific habitat management strategies to achieve those habitat goals and objectives; and utilizes key data, scientific literature, expert opinion, and staff expertise. The intent is that managers will have, in one document, a compendium of all the information needed to devise annual work plans and budgets for the refuge. The HMP also serves to inform and educate the public about the reasons the refuge exists, its priorities, and the resources (funds and personnel) it takes to manage a large, complex, and interconnected collection of habitats which in itself is only a small part of a larger, integrated landscape.

Global climate change is a transformational issue which is also being addressed through the implementation of the HMP. Over the last five years, refuges within the Southwest Louisiana National Wildlife Refuge Complex (Complex) were subjected to several high-water and wind events which included four named storms: Hurricanes Rita, Gustav, and Ike, and Tropical Storm Edouard. These storms were devastating to coastal marshes, including those on Sabine NWR. Powerful tropical systems, such as hurricanes, can create large, open-water areas in previously contiguous marshes which, when intact, would normally slow down destructive storm surges. Recent global climate change models predict that while tropical cyclone frequency may not change, or may decrease, the intensity of those storms will increase over time as surface sea temperatures increase (International Workshop on Tropical Cyclones 2006, Webster et al. 2005). Therefore, it is even more important to protect and restore marsh, both for its habitat value and also because it helps protect adjacent habitat, municipal structures, and oil and gas industrial infrastructure throughout coastal Louisiana. Without these marshes, wildlife, municipalities, and the local economy could be seriously jeopardized.

Climate change impacts, such as increased storm intensity, sea level changes, droughts, severe freezes, wildfires, and invasive species, may significantly alter management strategies over time. Natural resource managers must be flexible in adapting to change to fulfill the purposes for which the refuges within the Refuge System have been established.

B. REFUGE PURPOSE

The purpose for which Sabine NWR was established is set forth in the CCP (U.S. Fish and Wildlife Service 2007) as follows:

Executive Order 7764, dated December 6, 1937, stated the official purpose of the refuge: "...as a refuge and breeding ground for migratory birds and other wildlife." A secondary purpose of the refuge is: "...for use as an inviolate sanctuary, or for any other management purpose, for migratory birds" [16 U.S.C. 715d (Migratory Bird Conservation Act)].

Sabine NWR is managed according to goals, objectives, and strategies designed to maintain and restore habitat and manage water levels. Tools used to accomplish the refuge's goals and objectives include operating water control structures and prescribed burning. The primary management goal is to maintain and perpetuate Gulf coast wetlands for wintering waterfowl from the Mississippi and Central Flyways. The refuge is one of the largest estuarine-dependent marine species nurseries in southwest Louisiana (U.S. Fish and Wildlife Service 2002).

The management goals for Sabine NWR are to:

- Maintain and perpetuate refuge wetlands for wintering waterfowl (U.S. Fish and Wildlife Service 1998);
- Provide for the needs of endangered plants and animals;
- Allow compatible public uses, such as hunting, fishing, trapping, wildlife observation, and wildlife photography; and
- Promote research on marsh and aquatic wildlife (U.S. Fish and Wildlife Service 2002).

Similarly, the CCP laid out the following Vision for the refuge:

Sabine National Wildlife Refuge will maintain, restore, and enhance its unique coastal wetland habitats to provide favorable conditions for improving species diversity and richness of migratory birds and native terrestrial and aquatic species. In cooperation with partners, the refuge will also conserve healthy and viable wildlife and fish populations, thereby contributing to the purpose for which it was established and to the mission of the National Wildlife Refuge System.

C. LEGAL MANDATES

Legal mandates are discussed in detail in the Sabine NWR CCP (2007). However, a synopsis is warranted to give the reader some insight as to the legal authorities under which habitat management operates.

C-1: ESTABLISHMENT OF THE REFUGE

Sabine NWR was created in 1937 by Executive Order 7764 of President Franklin D. Roosevelt.

C-2: *FEDERAL LAWS, MANDATES, AND POLICIES*

Sabine NWR operates under a variety of laws and policy statements. The principle ones are listed as follows:

- National Wildlife Refuge System Administration Act of 1966
- Endangered Species Act
- National Wildlife Refuge System Improvement Act of 1997
- Title 50 of the Code of Federal Regulations
- U.S. Fish and Wildlife Service Manual – specifically 601 3(D2G), which states: Through the comprehensive conservation planning process, interim management planning, or compatibility reviews, determines the appropriate management direction to maintain and, where appropriate, restore biological integrity, diversity, and environmental health, while achieving refuge purpose(s).

Authority to control wildlife populations for management is governed as follows:

- Title 50 CFR 31, Section 14, states that animal species which are surplus or detrimental to the management program of a wildlife area may be taken in accordance with federal and state laws and regulations by federal or state personnel or by permit issued to private individuals, and animal species which damage or destroy federal property within a wildlife refuge area may be taken or destroyed by federal personnel.
- Title 50 CFR 30, Section 11 (a), states that feral animals, including horses, burros, cattle, swine, sheep, goats, reindeer, dogs, and cats, without ownership that have reverted to the wild from a domestic state, may be taken by authorized federal or state personnel or by private persons operating under permit in accordance with applicable provisions of federal or state law or regulation.
- Executive Order 13112 (Federal Register/Vol. 64 No. 25/Monday, February 8, 1999/ Presidential Documents 6183) states in Section 2, Federal Agency Duties, that we should: (i) detect and respond rapidly to and control populations of such species in a cost-effective and environmentally sound manner; (ii) monitor invasive species populations accurately and reliably; (iii) provide for restoration of native species and habitat conditions in ecosystems that have been invaded; (iv) conduct research on invasive species and develop technologies to prevent introduction and provide for environmentally sound control of invasive species.

D. **RELATIONSHIP TO OTHER PLANS**

In addition to the legal and policy mandates, management on Sabine NWR is influenced by other plans, those that are national or regional in scope, those that relate to activities of local entities, and those that relate to the refuge itself. Many of these plans are consistent with refuge goals and objectives, but, since different agencies have varying missions, it is inevitable that conflicts will arise.

When this occurs, the refuge will recognize the differences of opinions and take measures to address the other agency's concerns, where possible. However, the refuge will continue to manage with the mission, goals, objectives, and purpose of the refuge taking precedence.

D-1: NATIONAL AND REGIONAL PLANS

Gulf Coast Prairie Landscape Conservation Cooperative (LCC)

Sabine NWR will work with the following goal of SHC in the Gulf Coast Prairie LCC. Sabine NWR is in the Gulf Coast Prairie Landscape (Figure 2). The goal of SHC is to make natural resource management agencies more efficient and transparent, thereby making them more credible and wide-reaching in effect. Conservation efficiency may be thought of as the ratio of population impacts to management costs.

According to the recent memorandum of understanding (MOU) between the Service and the U.S. Geological Survey (USGS), both commit their respective leadership teams to adopt procedures and protocols to support the SHC framework's elements, and to develop shared capacity at the landscape level. The bureaus agree that each will engage additional partners to grow SHC expertise, involvement, and contribution. The Service and USGS will:

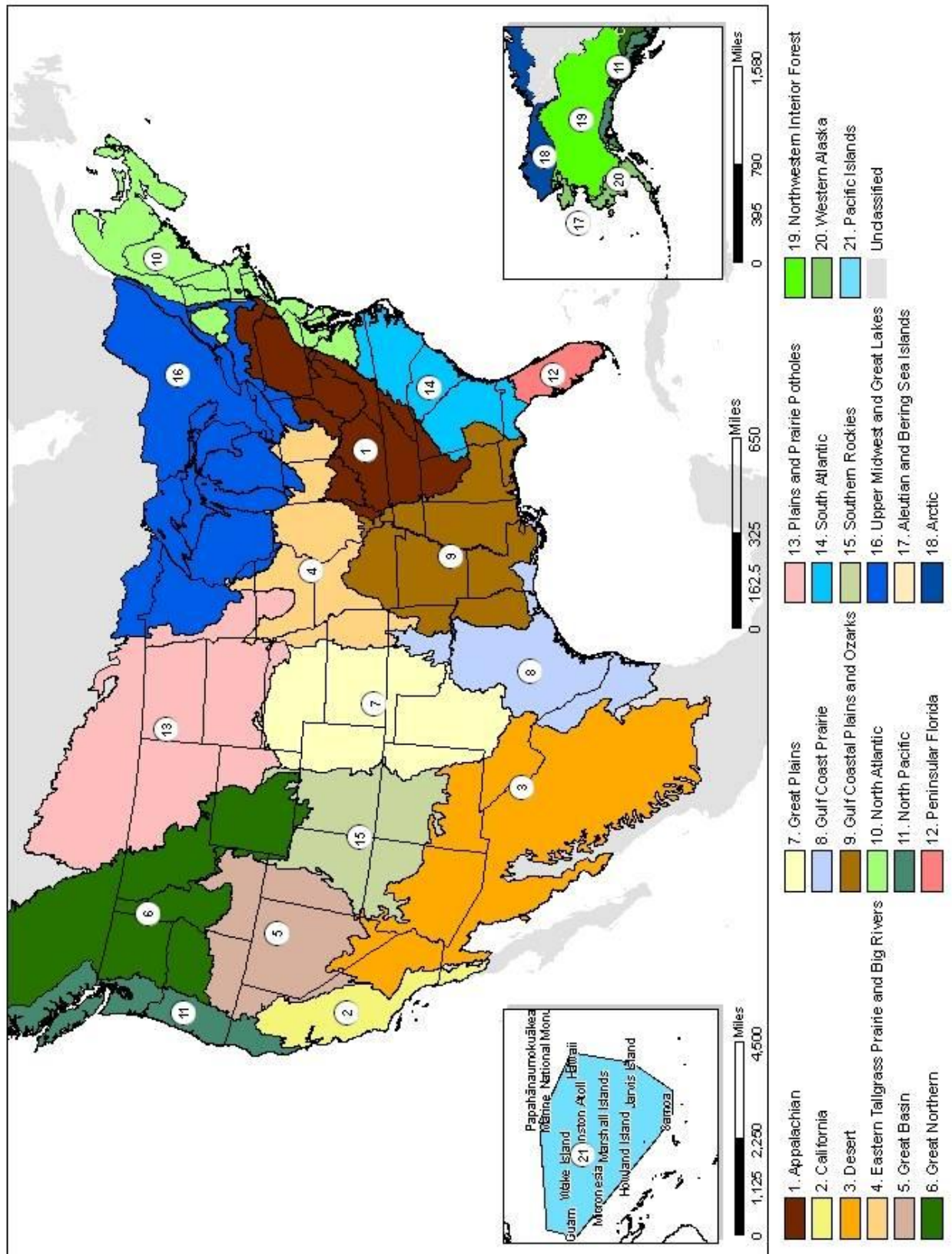
- Engage partners and the public in development of fish and wildlife population objectives;
- Develop and share scientific information to assess and forecast the functional landscapes needed to support fish and wildlife populations;
- Align programs and conservation efforts to contribute to population and landscape habitat conservation;
- Engage the best science along with management to design actions, measure outcomes, and continually refine and improve conservation results;
- Communicate shared efforts to implement science-based landscape conservation at a national scale.

The Gulf Coast Prairie LCC has recently hired a director and will be developing objectives and plans. Sabine NWR will engage and participate in this process and will contribute habitat and management actions that contribute to the goals established for the LCC.

North American Bird Conservation Initiative

The U.S. North American Bird Conservation Initiative (NABCI) is a forum of government agencies, private organizations, and bird initiatives helping partners across the continent protect, restore, and enhance populations and habitats of North America's birds. The Initiative's strategy is to foster coordination and collaboration on key issues of concern, including coordinated bird monitoring, conservation design, private land conservation, international conservation, and institutional support in state and federal agencies for integrated bird conservation. Sabine NWR will contribute to the goals of the NABCI by participating in the Gulf Coast Joint Venture and by continuing to provide high-quality wetland habitat for resident and wintering birds consistent with global and landscape-scale changes which affect habitat on the refuge.

Figure 2. Strategic habitat conservation landscapes



North American Waterfowl Management Plan

The North American Waterfowl Management Plan (NAWMP) was signed by the United States and Canadian governments in 1986 and with its update in 1994, Mexico became a signatory also. By promoting strategic restoration of wetlands and associated ecosystems across North America, the three nations are undertaking an intensive effort to protect and restore North America's waterfowl populations to levels observed in the 1970s.

Sabine NWR will contribute to the goals of the NAWMP by providing 125,790 acres of managed wetlands to sustain wintering ducks and geese, including mallard (*Anas platyrhynchos*), northern pintail (*A. acuta*), American wigeon (*A. americana*), green-winged teal (*A. crecca*), blue-winged teal (*A. discors*), northern shoveler (*A. clypeata*), Canada goose (*Branta canadensis*), snow goose (*Chen caerulescens*), and greater white-fronted goose (*Anser albifrons*).

North American Waterbird Conservation Plan

The North American Waterbird Conservation Plan was developed under a partnership, the Waterbird Conservation for the Americas, which is a group of individuals and organizations having interest and responsibility for conservation of waterbirds and their habitats in the Americas. Sabine NWR is located in the Southeast U.S. Regional Waterbird Conservation Planning Area. The refuge can contribute to a key objective of this region, which is to standardize data collection efforts and analysis procedures to allow better tracking of regional movements and the association of these movements with environmental or land use changes.

U.S. Shorebird Conservation Plan

The United States Shorebird Conservation Plan is a partnership involving organizations throughout the United States committed to the conservation of shorebirds. Sabine NWR is located within the Lower Mississippi Western Gulf Coast Shorebird Planning Region. On a regional scale, the refuge can help ensure that adequate quantity and quality of habitat is identified and maintained to support the different shorebirds that breed in, winter in, and migrate through the area. Sabine NWR manages 125,790 acres of marsh, which range from intermediate to brackish.

Partners in Flight Bird Conservation Plan

The National Fish and Wildlife Foundation led efforts in the 1990s to form the Partners in Flight program to combine resources and knowledge of many people to jointly protect the natural diversity of our continent. Many partners have made the program successful by participating in Working Groups to develop Regional Bird Conservation Plans. Sabine NWR is located within Coastal Prairie Physiographic Area 6, and can contribute to the plan's actions for marsh restoration projects to benefit migratory land birds.

Coastal Wetlands Planning, Protection, and Restoration Act

In 1990, Congress passed the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) that generates \$50 to \$60 million annually for Louisiana coastal wetland projects via an 85/15 federal-state cost share, and which provided for the development of the 1993 comprehensive Louisiana Coastal Wetlands Restoration Plan. Funding of proposed restoration projects is determined by the Louisiana Coastal Wetlands and Conservation and Restoration Task Force, which is composed of five federal agencies and the State of Louisiana. As mandated by CWPPRA, the task

force developed a detailed Coastal Wetlands Restoration Plan in 1993 that describes what restoration actions and projects should be implemented to address Louisiana's coastal land loss crisis. A Priority Project List is developed and approved by the task force each year, outlining which projects will receive CWPPRA funding. Sabine NWR has received \$24.4 million in CWPPRA funding, which has been used to support marsh restoration by beneficial use of dredge spoil. Another \$8.1 million in CWPPRA funding has been requested for completion of a beneficial dredge spoil project.

D-2: LOCAL AND STATE PLANS

Gulf Coast Joint Venture (Chenier Plain Initiative)

Regional partnerships or joint ventures composed of individuals; sportsmen's groups; conservation organizations; and local, state, provincial, and federal governments were formed under the NAWMP. One such partnership, the Gulf Coast Joint Venture (GCJV), formed to conserve priority waterfowl habitat range along the western United States Gulf coast, one of the most important waterfowl areas in North America. The Gulf coast is the terminus of the Central and Mississippi Flyways and provides both wintering and migrating habitat for significant numbers of the continental goose and duck populations. The GCJV's greatest contribution to the NAWMP is providing wintering grounds for waterfowl. A great diversity of birds, mammals, fish, shellfish, reptiles, and amphibians also rely on the wetlands of the Gulf coast for part of their life cycles.

The GCJV is divided geographically into six initiative areas, one of which is the Chenier Plain Initiative area of southwest Louisiana and southeast Texas. The goal of the Chenier Plain Initiative is to provide wintering and migrating habitat for significant numbers of dabbling ducks, diving ducks and geese (especially snow and greater white-fronted), as well as year-round habitat for mottled ducks (*Anas fulvigula*).

Sabine NWR provides 125,790 acres of diverse marsh and open-water habitats between September and February each year for migrating and wintering waterfowl to contribute to the population and habitat objectives listed in the GCJV's Chenier Plain Initiative (Esslinger and Wilson 2001). Winter population objectives of the plan include 4.5 million ducks and 500,000 geese for the entire Chenier Plain; although the plan does not quantify goals for coastal marsh, it supports marsh restoration and protection initiatives in the region (CCP Objective B-1). Winter populations of ducks on the refuge in recent years range between 100,000 and 200,000, representing 2 to 4 percent of the regional population goal. Waterfowl foods in Management Unit 3 have been found to be available at densities significantly above the level required for efficient waterfowl use. The refuge has, since 2002, restored nearly 1,000 acres of intermediate to brackish marsh by beneficial use of dredge spoil. In addition, the refuge has constructed 221,000 linear feet of earthen terraces in open-water areas susceptible to the erosive effects of wave action and saltwater intrusion. Terraces are constructed for the purpose of reducing wave action, trapping sediments, and improving the habitat for submerged aquatic vegetation. Secondary benefits include the creation of nesting habitat for least terns, Forster's terns, and black skimmers, and the improvement of aquatic habitat for fish (U.S. Fish and Wildlife Service 2007).

Coast 2050: Towards a Sustainable Coastal Louisiana

Coast 2050 is a comprehensive, ecosystem-based plan developed to address coastal wetland loss throughout southern Louisiana by private citizens, local, state and federal agencies, and the scientific community. Coast 2050, which is recognized by the State of Louisiana, five federal agencies, and local coastal parish governments, serves as the joint coastal restoration plan for CWPPRA. The goals of Coast 2050 are to assure vertical accumulation (soil, vegetation, and other organic material)

to achieve sustainability, maintain estuarine gradient to achieve diversity, and to maintain exchange and interface to achieve system linkages. Sabine NWR is included in Region 4 of this plan.

Louisiana Coastal Area Ecosystem Restoration Plan

The Louisiana Coastal Area Ecosystem Restoration Plan (LCA) evolved from the Coast 2050 Plan, with the overarching goal of reversing the current trend of degradation of the coastal ecosystem. LCA formed the basis for the Louisiana Coastal Area Ecosystem Restoration Study, designed to identify critical ecological needs, identify restoration efforts, establish restoration priorities, and identify scientific uncertainties to present a strategy for addressing long-term needs of coastal Louisiana restoration.

Sabine NWR is located within Sub-province 4 of LCA. The restoration plans identified in LCA relate directly and indirectly to the refuge through long-term efforts to explore large-scale restoration projects that will influence the entire coastal zone of Louisiana.

Louisiana Comprehensive Wildlife Conservation Strategy (Wildlife Action Plan)

The Louisiana Department of Wildlife and Fisheries produced the state's wildlife action plan in 2005 (Lester et al. 2005). This plan details the conservation needs and strategies for aquatic and terrestrial systems across the state, and lists a number of high-priority actions for imperiled species and systems. In the Coast Prairies and Marshes ecoregion, intermediate and brackish marsh are listed as high priorities for action because of threats to their viability from saltwater intrusion and from hydrologic alterations due to construction of roads, canals, ditches and drainage systems, levees, and oil and gas development. Coastal prairie is a critically imperiled system which has been lost over more than 99 percent of its former range because of land use conversion and fire suppression. Strategies described in this document that Sabine NWR supports include:

Coastal Prairie

- Partner with non-governmental organizations, state and federal agencies, private landowners, etc., to promote protection, restoration, and expansion of coastal prairie habitat.
- Promote fire as [an] essential management tool. Burn these areas as needed and promote alternatives to fire where prescribed burning is not an option.

Freshwater Marsh

Shorebirds, Wading Birds

- Provide public education regarding the importance of waterbird nesting colonies and shorebird feeding areas. Reduce the negative effects on these areas from recreational and other uses.
- Work with landowners to implement management and conservation recommendations for waterbirds (especially rails).

Waterfowl

- Continue to encourage the creation/enhancement/maintenance of high-quality habitat across Louisiana.
- Work with Ducks Unlimited, Delta Waterfowl, and the Service to assure that quality habitat, including refuge from hunting and other disturbance, is distributed across the landscape.

Intermediate Marsh

Habitat

- Work with Corps of Engineers and state agencies to ensure water control structures provide the maximum benefit to intermediate marsh.
- Work with LCA and CWPPRA for protection and restoration of intermediate marsh.

Shorebirds, Wading Birds

- Disturbance and loss of nesting habitat are major threats to these species. Continue to protect and restore coastal marshes. Develop new and/or improve existing partnerships to achieve this goal.

Waterfowl

- Continue to encourage the creation/enhancement/maintenance of high-quality habitat across Louisiana.
- Work with Ducks Unlimited, Delta Waterfowl, and the Service to assure that quality habitat, including refuge from hunting and other disturbance, is distributed across the landscape.

Brackish Marsh

Habitat

- Work with LCA, CWPPRA to support coastal restoration projects, specifically targeting important waterbird nesting areas and species of conservation concern.
- Work with Corps of Engineers and state agencies to ensure water control structures provide the maximum benefit to brackish marsh.

Shorebirds, Wading Birds

- Coordinate with GCJV to implement recommendations of shorebird and wading bird conservation plans.
- Disturbance and loss of nesting habitat are major threats. The continued protection and restoration of coastal marshes are top priorities. Develop new and/or improve existing partnerships to achieve this goal.

Waterfowl

- Continue to encourage the creation/enhancement/maintenance of high-quality habitat across Louisiana.
- Work with Ducks Unlimited, Delta Waterfowl, and the Service to assure that quality habitat, including refuge from hunting and other disturbance, is distributed across the landscape.

II. Environmental Setting and Background

A. LOCATION

Sabine NWR is about 32 miles south of Lake Charles, Louisiana, in western Cameron Parish. The refuge is one of four administered through the Southwest Louisiana NRW Complex (Figure 1), and comprises 125,790 acres of mostly intermediate and brackish marsh, including 100 acres of small coastal prairie islands and 740 acres of artificial upland habitat (levees and spoil banks) (Table 1).

B. MANAGEMENT COMPARTMENTS AND DESCRIPTIONS

Sabine NWR is divided into 13 management units (Figure 3). Habitat type, size, soil type, current condition, and past management history for each unit are described in Table 1 and Appendix C.

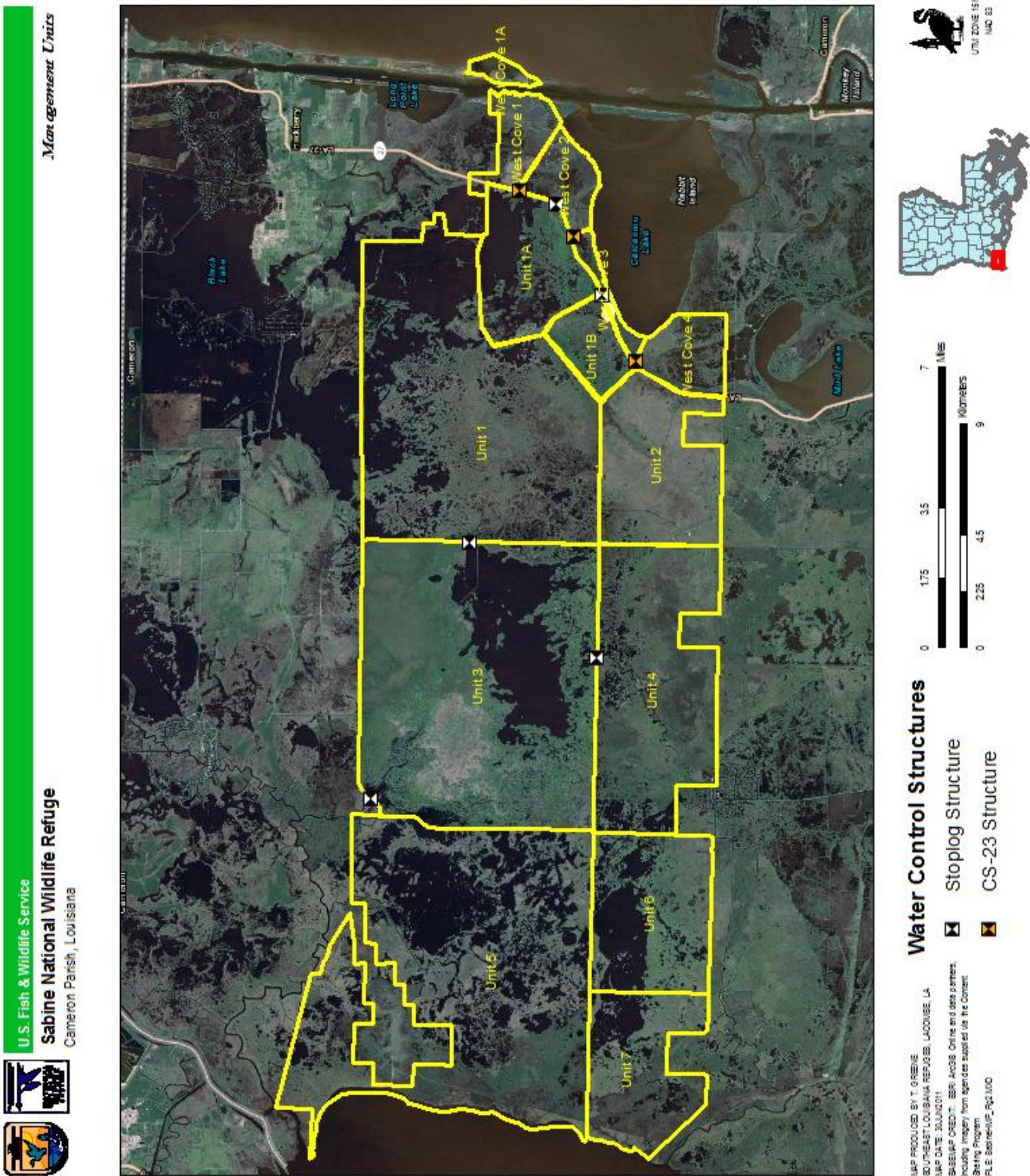
Table 1. Description of 13 Management Units on Sabine NWR

Unit	Size, Acres	Habitat Type	Current Condition	Treatment History
1	23,277	Unimpounded brackish to intermediate marsh	Mix of brackish and intermediate marsh. Newly restored marsh exists in eastern side of unit. Unit is open to flow from Calcasieu Lake.	Records and recorded data lost during Hurricanes Rita and Ike
1A	5,269	Impounded brackish to intermediate marsh	Historically a freshwater impoundment, this unit is currently brackish to intermediate marsh. Levees have been repaired after Hurricane Rita, and stoplog structures are functional.	Records and recorded data lost during Hurricanes Rita and Ike
1B	2,058	Impounded brackish to intermediate marsh	Historically a freshwater impoundment, this unit is currently brackish to intermediate marsh. Levees have been repaired after Hurricane Rita, and stoplog structures are functional.	Records and recorded data lost during Hurricanes Rita and Ike

Unit	Size, Acres	Habitat Type	Current Condition	Treatment History
2	7,124	Unimpounded intermediate marsh	Unit 2 is mostly intermediate marsh. Saltwater intrusion from the southeast (Calcasieu Lake) is gradually transforming the unit from fresh marsh to brackish.	Records and recorded data lost during Hurricanes Rita and Ike
3	26,402	Impounded brackish to intermediate marsh	Historically a freshwater impoundment, this unit is currently brackish to intermediate marsh. Levees have been repaired after Hurricane Rita, and stoplog structures are functional.	Records and recorded data lost during Hurricanes Rita and Ike
4	12,654	Unimpounded intermediate marsh	Unit is mostly intermediate marsh.	Records and recorded data lost during Hurricanes Rita and Ike
5	28,023	Unimpounded brackish to intermediate marsh	Unit is mostly intermediate marsh, with brackish marsh in the northern and western portions.	Records and recorded data lost during Hurricanes Rita and Ike
6	7,496	Unimpounded intermediate marsh	Unit is mostly intermediate marsh.	Records and recorded data lost during Hurricanes Rita and Ike
7	6,254	Unimpounded brackish to intermediate marsh	Unit has intermediate marsh on the east side and brackish marsh on the west.	Records and recorded data lost during Hurricanes Rita and Ike

Unit	Size, Acres	Habitat Type	Current Condition	Treatment History
West Cove 1	3,741	Unimpounded brackish to intermediate marsh	Unit is brackish marsh and is open to Calcasieu Lake	Records and recorded data lost during Hurricanes Rita and Ike
West Cove 1A	498	Unimpounded brackish to intermediate marsh	Unit is brackish marsh and is open to Calcasieu Lake	Records and recorded data lost during Hurricane Rita and Ike
West Cove 2		Unimpounded brackish to intermediate marsh	Unit is brackish marsh and is open to Calcasieu Lake	Records and recorded data lost during Hurricanes Rita and Ike
West Cove 3	686	Unimpounded brackish to intermediate marsh	Unit is brackish marsh and is open to Calcasieu Lake	Records and recorded data lost during Hurricanes Rita and Ike
West Cove 4	2,308	Unimpounded brackish to intermediate marsh	Unit is brackish marsh and is open to Calcasieu Lake	Records and recorded data lost during Hurricanes Rita and Ike

Figure 3. Sabine NWR management units



C. PHYSICAL AND GEOGRAPHIC SETTING

C-1: CLIMATE

The climate at Sabine NWR can be described as subtropical with short, mild winters and hot, humid summers, with no substantial spring or fall seasons. Summer weather patterns usually begin in April and prevail for seven months. Global climate change has the potential to drastically alter habitats in low-lying areas of the Gulf coast. Climate change for the Service's Southeast Region is discussed in Appendix H.

C-2: TEMPERATURE

Summer temperatures (°F) range from the low 70s to the upper 80s and into 90s during the afternoon. November may have cool days, but winter weather typically starts in December and lasts through March. Average temperatures during the winter range from lows in the 40s to highs in the mid 60s. Temperature extremes (1939-2005) range from a low of 11°F on February 2, 1951, to a high of 106°F on September 1, 2000 (National Climatic Data Center 2010).

C-3: PRECIPITATION

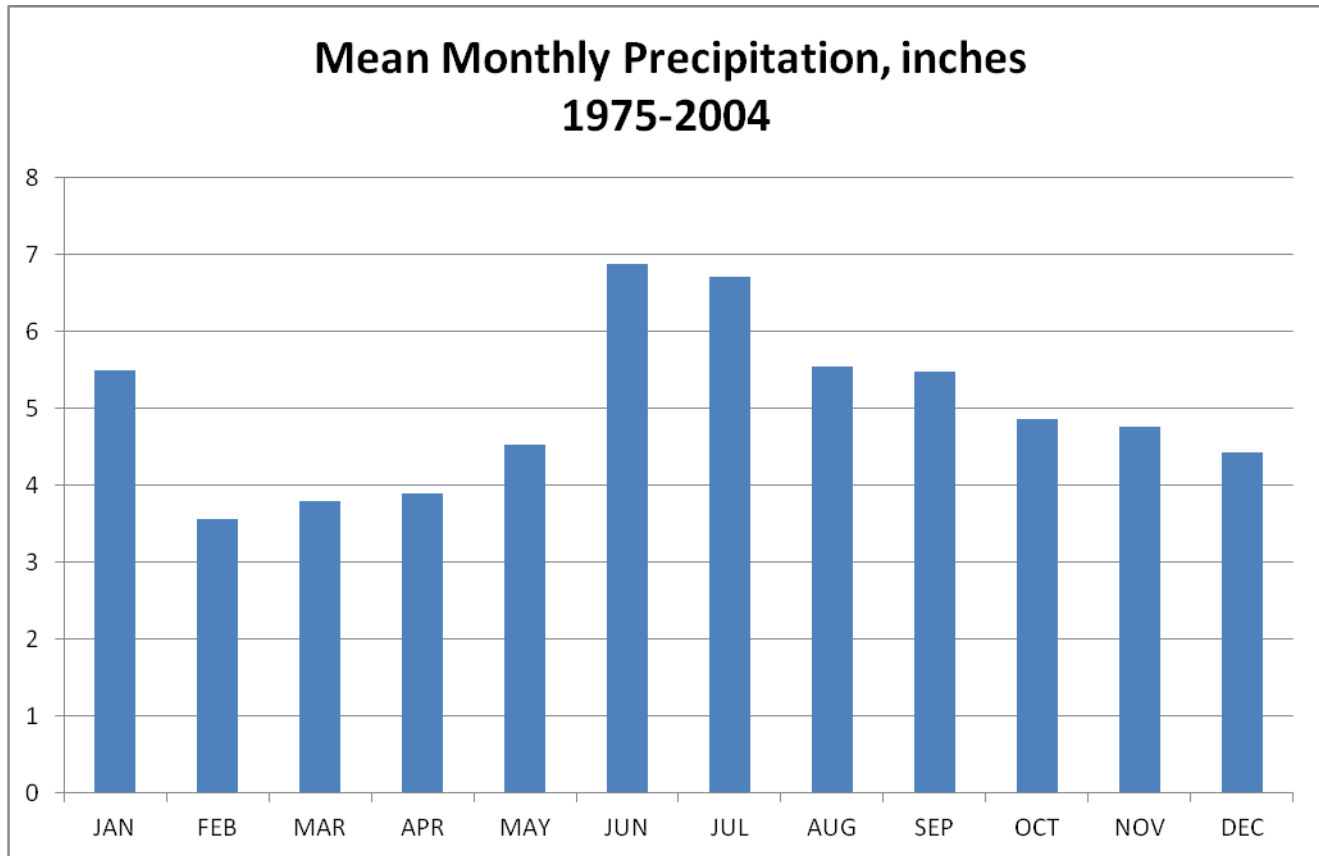
The average annual precipitation, as recorded at West Cove on Sabine NWR for the period 1975-2005 is 59.96 inches (National Climatic Data Center 2010). Rainfall follows a weak bimodal distribution, with a strong peak in June and July and a smaller peak in January. February-April is the driest period on the refuge (Figure 4). Summer weather patterns and associated southwest winds bring moist, warm air on shore from the Gulf of Mexico, leading to the formation of thunderstorms. These rainfall events are short-duration, high-intensity, localized storms. From November to February, the weather patterns are influenced by cold continental air masses. Rainfall during this period comes from the effects of frontal passages. Rain events are more widespread and less intense than those in the summer. Annual precipitation amounts can vary widely. Over a 30-year period from 1975 to 2004, total annual rainfall ranged from 42.76 inches to 80.45 inches. These fluctuations in precipitation can impact refuge management operations to a great extent.

Wet conditions make the maintenance of unpaved roads difficult if not impossible. They also result in decreased opportunities for prescribed burning and can complicate efforts to dewater impoundments. Drought years can also have profound effects on habitat and management; impoundments can dry out, and wildfire risk increases. Reduced rainfall over extended periods causes reduced inflow of freshwater, and thus increases the potential for saltwater intrusion through natural and man-made channels. Thus, if climate change results in drier conditions for all or part of the year on average, higher salinities, and consequent conversion of habitat types to more salt-tolerant systems can be expected.

C-4: ATMOSPHERIC MOISTURE

As would be expected, with large bodies of water in and around the refuge, relative humidity (RH) is typically high. Morning mean RH is generally between 88 and 95 percent throughout the year, while readings in the mid-afternoon are between 55 and 67 percent. RH values of 100 percent are not uncommon.

Figure 4. Monthly average precipitation over 30 years at West Cove, Sabine NWR



C-5: LIGHTNING

Due to its importance in fire management, a refuge management activity, lightning deserves to be addressed. Vaisala's National Lightning Detection Network states that southwest Louisiana has an 8 to 10 average flash per sq. km/yr. (Vaisala NLDN Poster). Vaisala NLDN Poster data estimate that over 22,000 lightning strikes occur in southwest Louisiana each year. Lightning is the main source of ignition for non-anthropogenic fires on Sabine NWR; between 2000 and 2011, 147 of 209, or 70 percent of ignitions on Sabine NWR were caused by lightning. Those fires were responsible for burning 94,072 acres on the refuge, compared with 38,534 acres burned by fires ignited by all other causes (M. Johnson, pers. comm.).

C-6: TROPICAL CYCLONES

On September 24, 2005, Hurricane Rita, a Category 3 hurricane, moved across southwest Louisiana with winds in excess of 100 knots, leaving a panoptic path of destruction in its wake (Figure 5). As a measure of the power of its destructive impact to one key industry alone, Hurricane Rita demolished 69 offshore oil and gas platforms and four drilling rigs, and extensively damaged another 32 platforms and 10 drilling rigs.

Hurricane Ike came ashore on September 13, 2008. A storm surge larger than Hurricane Rita's caused considerable damage to the refuge. Saltwater intrusion, as well as persistent flooding on the refuge for weeks, led to major losses of flora and fauna alike. Recovery of vegetation and wildlife has shown progress through 2012.

Tropical cyclones are an important feature of the climate of southwest Louisiana. Tropical storms strike the southwestern Louisiana/southeastern Texas coast on the average every 1.6 years, and hurricanes every 3.3 years (Roth 1998). These storms have shaped the landscape, vegetation, and ecology of the area for millennia, and continue to do so today. Storm surges can completely reshape coastal landforms, and periodic inundation with saltwater restricts the range of vegetation types that can occupy an area. High winds associated with these storms also affect growth forms of woody vegetation, favoring windfirm species like baldcypress and longleaf pine, and those with above-ground growth forms that are resistant to wind, like live oak, and providing disturbance which increases biodiversity (Merry et al. 2009, Mitchell and Duncan 2009).



Figure 5. Hurricane Rita (NASA)

Sabine NWR lies between 4 and 18 miles from the coast, and elevations range from 0-4 feet above msl. This means that the entire refuge is subject to inundation in even moderate storm surges, and high winds and rain associated with tropical cyclones can be expected as well. Intensification of tropical cyclones associated with global climate change will likely increase the effects on the refuge.

C-7: AIR QUALITY

Sabine NWR is considered to be a clean air area under the Clean Air Act. This means that limited development (i.e., additional sources of pollution) can be permitted near the refuge as long as the levels of particulate matter, sulfur dioxide, and nitrogen dioxide do not exceed the class II increments. The ambient air quality is influenced by prescribed burning and wildfires, vehicle traffic, and off-site emission sources. Off-site sources include traffic on the Gulf Intracoastal Waterway (which passes north of the refuge) and on ship channels to the east and west, oil and gas operations, refineries and chemical plants in nearby Port Arthur, Texas, and Sulphur/Lake Charles, Louisiana, and the Gulf menhaden processing plant in Cameron, as well as prescribed burning and wildfires which occur off-refuge.

C-8: GEOMORPHOLOGY AND TOPOGRAPHY

The Chenier Plain of southwestern Louisiana is a geologically young (Holocene) region characterized by cheniers or sandy ridges, which lie parallel to the shoreline. Cheniers are the remains of ancient shorelines that formed after the sea level rose to its current level following the most recent glaciation and as sediments were deposited by the Mississippi River over the past 600 to 2,800 years (Louisiana Geological Survey staff 2008, Spearing 1995). This region stretches from extreme southeast Texas, to 120 miles eastward into south-central Louisiana, and reaches inland 10-20 miles. Elevations range from sea level to 20 feet. Cheniers historically supported stands of oaks (the word

chenier comes from French word “chêne,” which means “oak”). Between the cheniers lie freshwater marshes bisected by rivers and bayous draining the adjacent uplands to the north (Penland and Suter 1989, Spearing 1995).

Underlying much of Louisiana, including the Chenier Plain, is the Louann Salt, a layer of ancient salt deposits left as a shallow inland sea, which became the Gulf of Mexico, repeatedly evaporated and re-filled during Triassic and Jurassic time (245-144 million years before present). Salt from this layer, which is thousands of feet thick, has intruded upwards 10 miles through overlying alluvial sediment and formed “salt domes,” several of which are found on the Chenier Plain. Salt domes are best known for their role in trapping and accumulating petroleum, and some are significantly elevated above the surrounding landscape (Spearing 1995). The town of Hackberry, northeast of the refuge, is located on a salt dome.

C-9: HYDROLOGY

In wetland systems like Sabine NWR, hydrology is probably the most important driver of ecological processes. Sabine NWR is a tidally influenced system. Tidal flow from the Gulf of Mexico passes through Sabine Pass and the Calcasieu Ship Channel into Sabine Lake and Calcasieu Lake, respectively, and thence onto the west and east sides of the refuge. Tidal amplitude in the Gulf of Mexico is normally small (less than 1 foot), but storms and surface winds often augment tidal flow. Storm surges in recent hurricanes have exceeded 10 feet. Prolonged, steady south or north winds associated with weather systems can inundate or dewater large portions of the refuge. The main source of freshwater is the Sabine River, which flows into Sabine Lake and feeds freshwater into the Gulf Intracoastal Waterway northwest of the refuge. Freshwater also flows onto the northwestern portion of the refuge from freshwater marsh in southeastern Calcasieu Parish.

During dry periods, saltwater intrusion through the Calcasieu Ship Channel significantly increases salinity levels on the eastern half of Sabine NWR. Over time, unimpounded marsh in this area has shifted from fresh to intermediate or brackish types in response to elevated salinity. Impounded areas in Units 1A, 1B, and 3 were inundated with saltwater during Hurricane Rita in 2005 and Hurricane Ike in 2008. Although levee breaches have been repaired at Unit 3, no attempt has been made since that time to impound freshwater in these areas, and the vegetation and fauna are in the process of shifting to salt-tolerant communities near water control structures and spillways. The CS-23 Water Control Structures, located along Highway 27, were heavily damaged by Hurricane Rita, and they are being replaced. The new structure at Hog Island Gully is operational; Headquarters Canal and West Cove Canal are expected to be operational in 2012.

C-10: SOILS

Soils on Sabine NWR range from upland, mineral soils which developed under grassland to organic mucks of salt marshes. All are poorly drained and relatively fine-textured (Table 2).

Table 2. Classification and characteristics of soil series found on Sabine NWR; all information taken from Soil Conservation Service (1995)

Series	Classification	Description	Management Considerations
Aquents, frequently flooded		Frequently flooded, hydraulically excavated loamy and clayey material deposited in wetlands	Most areas of aquents are used for wildlife habitat; repeated deposition of spoil material limits use and sets back succession on these areas
Allemands muck	Clayey, montmorillonitic, euic, thermic Terric Medisaprists	Frequently flooded, very poorly drained organic soils of freshwater marshes	Allemands muck is suitable for wildlife habitat, but not for crop production due to severe restrictions imposed by poor drainage and shrinkage/subsidence potential
Bancker muck	Very fine, montmorillonitic, nonacid, thermic Hydraquents	Very poorly drained, very slowly permeable, slightly saline, very fluid, mineral soils in brackish marshes.	Bancker soils are ponded most of the year and are not suited for crop production or pasture. Most use is for wetland wildlife habitat and recreation.
Clovelly muck	Clayey, montmorillonitic, euic, thermic Terric Medisaprists	Very poorly drained, very slowly permeable, organic soils of brackish marshes	Clovelly soils are not suited for crops or pasture; limitations are flooding, ponding, and salinity.

Series	Classification	Description	Management Considerations
Creole mucky clay	Fine, montmorillonitic, nonacid, thermic Typic Hydraquents	Very poorly drained, very slowly permeable, slightly saline or moderately saline soils in coastal brackish marshes	Creole soils are not suited for crops or pasture; limitations are flooding, ponding, and salinity. These soils are moderately suited for rangeland; however, associated soils (Bancker, Larose, Scatlake) have low, load-bearing properties and pose an entrapment hazard for cattle. Creole soils are well suited for wildlife habitat.
Ged mucky clay	Very fine, mixed, thermic Typic Ochraqualfs	Very poorly drained, very slowly permeable soils of freshwater marshes	Ged mucky clay is suitable for wildlife habitat, or if properly drained and managed, for rice production.
Gentilly muck	Very fine, montmorillonitic, nonacid, thermic, Typic Hydraquents	Very poorly drained, very slowly permeable, slightly saline, fluid mineral soils of brackish marshes.	Gentilly muck is slightly saline and ponded most of the time. Load-bearing capacity is low, limiting suitability for livestock. Most areas of Gentilly muck are used for wildlife habitat and/or recreation.
Larose muck	Very fine, montmorillonitic, nonacid, thermic, Typic Hydraquents	Level, very poorly drained, very slowly permeable, very fluid mineral soils of freshwater marshes.	Larose muck is usually ponded and has a low load-bearing capacity. Most areas of Larose muck are used for wildlife habitat and recreation.

Series	Classification	Description	Management Considerations
Mermentau clay	Clayey over loamy, montmorillonitic, nonacid, thermic Typic Haplaquepts	Poorly drained, moderately saline or strongly saline, very slowly permeable mineral soils on low ridges and broad areas of brackish marsh.	Mermentau clay is moderately well suited for use as rangeland for cattle and for wildlife habitat.
Midland silty clay loam	Fine, montmorillonitic, thermic, Typic Ochraqualfs	Poorly drained, very slowly permeable soils formed in late Pleistocene clayey and silty alluvium	Midland soils occur on broad flats and slight depressions. This soil is moderately well suited for crop production, and well suited for pasture. Cultivation is only possible within a narrow range of moisture content. On Sabine NWR, this soil occurs on isolated prairie islands surrounded by marsh.
Morey silt loam	Fine-silty, mixed, thermic Typic Argiaquolls	Poorly drained, slowly permeable soils in loamy and clayey late-Pleistocene alluvium	This soil is moderately well suited for crop production, limited by wetness and medium fertility, and well suited for pasture. Morey soil is friable and responds well to tillage; however, traffic when the soil is wet will cause formation of a traffic pan. On Sabine NWR, this soil occurs on isolated prairie islands surrounded by marsh.

Series	Classification	Description	Management Considerations
Mowata silt loam	Fine, montmorillonitic, thermic Typic Glossaqualfs	Poorly drained, very slowly permeable soils in loamy and clayey late-Pleistocene alluvium	This soil is moderately well suited for crop production, limited by wetness and medium fertility, and well suited for pasture. Crusting and a tendency to form traffic pans also limit the agricultural uses of this soil. On Sabine NWR, this soil occurs on isolated prairie islands surrounded by marsh.
Scatlake mucky clay	Very fine, montmorillonitic, nonacid, thermic Typic Hydraquents	Very poorly drained, very slowly permeable, moderately saline and strongly saline, very fluid, mineral soils	This is level, very poorly drained, very fluid mineral soil in saline marshes. It is suited for wetland wildlife habitat and recreation, but has severe limitations for other uses.
Udifluvents, 1 to 20 percent slopes		Sandy, loamy, or clayey soil material which has been excavated from marshes and deposited in spoil banks.	Uses variable; often utilized by wildlife. Vegetation consists of ruderals, exotics, and woody species adapted to higher landscape positions.

C-11: CHANGING ENVIRONMENTAL CONDITIONS

Among the most serious consequences of forecast climate change are sea level rise and the likely increase in hurricane intensity and associated storm surge (U.S. Global Change Research Program 2009). Global sea level is projected to rise during the 21st century at a greater rate than during 1961 to 2003 (Intergovernmental Panel on Climate change 2007). The result will be shoreline retreat and inundation of inland areas. Subsidence, or land sinking, also contributes heavily to coastal erosion and land loss in Louisiana and the surrounding Gulf states. Geological modeling has suggested that the weight of Pleistocene sediments on the coast of Louisiana can explain between 0.1 and 0.8 centimeters (0.04 and 0.3 inches) of sinking per year (NASA 2008). Other impacts of sea level rise include increased risks of erosion, conversion of wetlands to open water, increase in salinity of estuaries and freshwater aquifers, and flooding for coastal communities (NASA 2009). Rising sea temperatures are expected to increase the frequency and strength of hurricanes (Emanuel 2005). Stronger storms with higher wind speeds, more intense rainfall, and more powerful surges are expected to cause more severe damage (Knutson and Tuleya 2004).

Increasing intensity and frequency of storms, combined with sea level rise and local land subsidence, mean that over time, Sabine NWR and the surrounding lands will become more saline and more frequently inundated by saltwater or brackish water. Management of freshwater impoundments will become increasingly difficult, as evidenced by recent inundations of impoundments on the refuge. As sea level rises and salinities increase, vegetation zones will migrate inland; present salt marsh will convert to open water, brackish marsh will become saline, freshwater marsh will become brackish, and freshwater swamps and shrub communities will convert to herbaceous systems as episodes of saltwater intrusion become more frequent and occur further inland. Change is inevitable; management of the refuge will need to be flexible and adaptive to continue to successfully fulfill the purpose for which it was established.

C-12: FLYWAYS

Sabine NWR and the western Gulf Coast are a part of the Mississippi Flyway (Figure 6), and have influence and exchange from the Central Flyway (Figure 7). The Mississippi and Central Flyways are corridors for over two-thirds of waterfowl species in North America. Coastal marshes of these flyways are an irreplaceable habitat resource for wintering waterfowl. The region serves both as wintering habitat for dozens of species of waterfowl and high-quality stopover habitat for many more which migrate to the tropics.

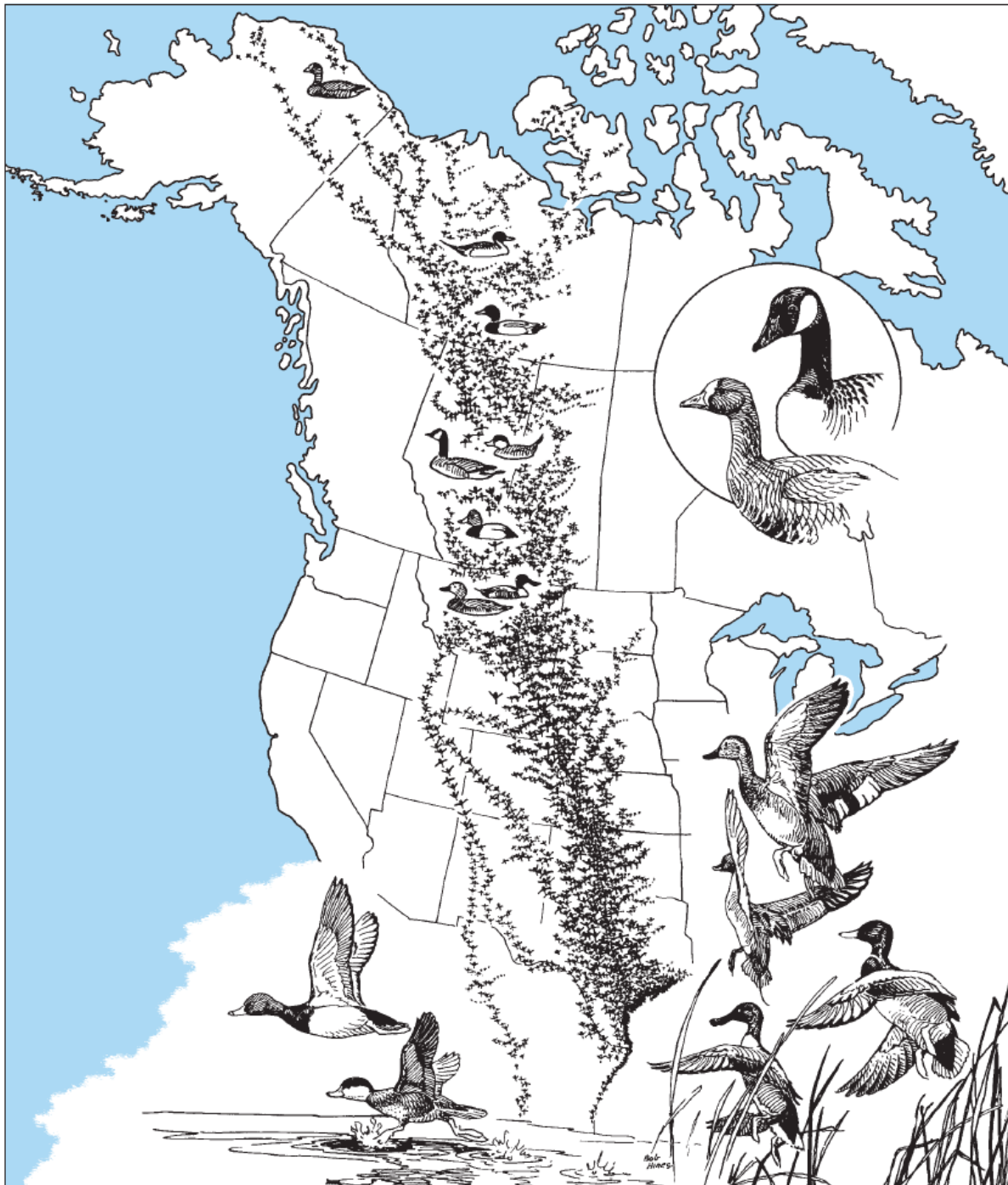
Figure 6. Mississippi Flyway



Figure 7. Central Flyway

U.S. Fish & Wildlife Service

Central Flyway



D. CULTURAL AND REFUGE LAND HISTORY

D-1: PREHISTORIC HUMAN OCCUPATION

Prior to the arrival of Europeans, the area of southwestern Louisiana now occupied by Sabine NWR was inhabited by the Atakapa Indians. The Atakapa people were hunters, fishers, and gatherers whose livelihood depended on the productivity of wetland and aquatic ecosystems in southwestern Louisiana and southeastern Texas. When Spanish explorers arrived the Atakapa people had occupied the area for at least two millennia, but they succumbed quickly to European diseases and were mostly gone by the start of the 19th Century (Haggard no date). It can be assumed that the Atakapans, like other prehistoric North American peoples, used fire as a tool to manage their landscape, and they probably had the effect of decreasing the fire return interval on lands that they burned (Pyne 1982). There is no evidence that they were agriculturists (Aten and Bollich no date); indeed, most of the area that is now Sabine NWR would not have been suitable for agriculture or permanent human habitation because of recurring flooding. Therefore, these prehistoric peoples' effects on habitat would probably have been limited to favoring fire-maintained vegetation types and would not include large areas of soil disturbance associated with agriculture or permanent settlements, such as is seen with prehistoric North Americans in other regions.

D-2: HISTORIC HUMAN OCCUPATION

Spanish exploration of the Gulf coast began as early as 1502, and by the end of the 17th Century, Spanish and French settlements had been established in what was to become Louisiana (Kniffen 1968). France ceded Louisiana to the Spanish in 1763, but regained control of the territory east of the Red River, exclusive of the Florida Parishes, in 1803, prior to its sale to the United States later that year. However, the southwestern portion of what is now Louisiana was claimed by France and Spain, and remained a "no man's land" known as the "Neutral Ground" until 1821, when it became part of the United States (Handbook of Texas Online 2010).

European colonization of southwestern Louisiana began in earnest after the Acadians were expelled from British Canada and began to settle in the area in 1765. The Acadians, or "Cajuns," as they became known, were farmers, herders, fishers, and hunters, and began transforming the landscape to further those pursuits (Hebert 2003). Immigrants of many origins, including Native Americans from other regions of the continent, African-American, African-Caribbean, English, German, Irish, and Spanish joined the Acadians in southwestern Louisiana, and contributed to the unique culture found there today (Owens 1997).

Conversion to an agricultural landscape began during this period, causing fragmentation and eventual loss of prairie habitats which existed to the north of what is now Sabine NWR, increased sediment inputs into streams, and changes in hydrology related to irrigation structures and drainage ditches. During the 20th century, hydrologic modifications intensified; waterways were dredged, straightened, bypassed, and channelized in order to improve navigation, drainage, irrigation, and water supply. Today, two major shipping corridors bracket the refuge on the east and the west, facilitating the movement of commerce as well as saltwater into formerly freshwater systems. Commercial harvest of fish and shellfish has transformed the ecology of the near-shore ocean, and coastal wetlands are being lost at unprecedented rates, despite their critical importance to both terrestrial and marine environments.

D-3: RECENT HISTORY

- 1873; Calcasieu Pass is dredged
- 1926; First producing oil and gas well (well No. 5215) in Cameron Parish was the Pure Oil Company's Fount Lee No. 3
- 1934; The Gulf Intracoastal Waterway was completed at its present location, creating a dredged waterway north of what was to become the refuge.
- 1937; Sabine NWR was created by Executive Order.
- 1941; Calcasieu Ship Channel extended to Lake Charles
- 1951-1959; Construction of freshwater impoundments in Units 1A, 1B, and 3
- 1989; Construction of levee and water control structures in Calcasieu Lake
- 2002; First use of beneficial dredge material on Sabine NWR
- 2005; Hurricane Rita
- 2008; Hurricane Ike
- 2011; Completion of the CS-23 Water Control Structures

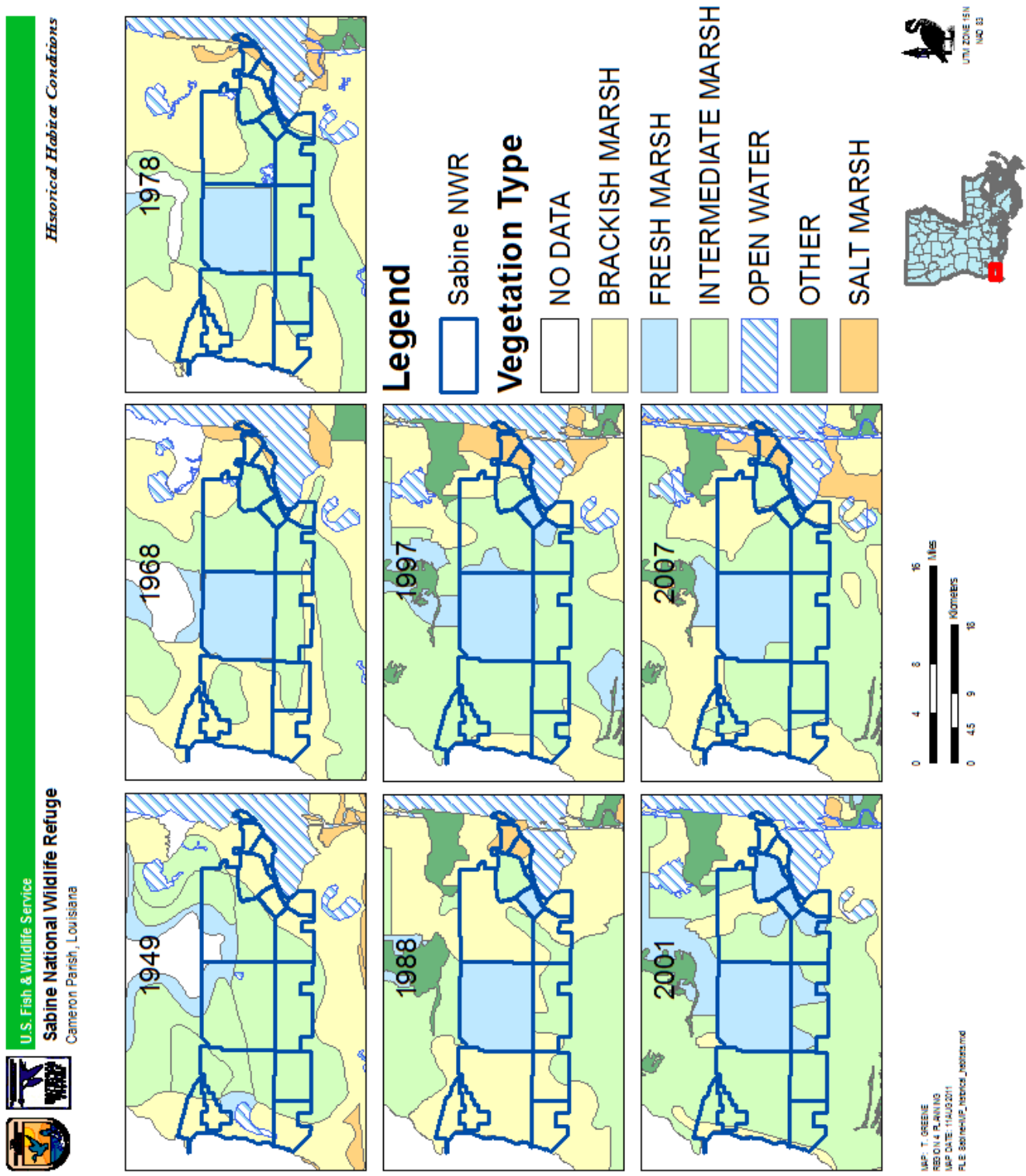
D-4: PREHISTORIC HABITAT CONDITIONS

Before southwestern Louisiana was colonized by European settlers, the land currently occupied by Sabine NWR probably ranged from brackish marsh on the southern portions and near Sabine and Calcasieu Lakes to freshwater marsh to the north. Vegetation was mostly herbaceous, maintained by frequent fires caused by lightning and early human occupants. Small inclusions of coastal prairie presumably existed on high ground adjacent to Sabine Lake.

D-5: HISTORIC HABITAT CONDITIONS

Since the mid-20th Century, marsh vegetation has been monitored on and around Sabine NWR. The location and extent of fresh, intermediate, brackish, and saline marsh have fluctuated over this time period as a result of human activities (e.g., dredging, levee construction) as well as natural processes including coastal subsidence, storms, and drought. The map series in Figure 8 shows salinity-induced fluctuations in vegetation on Sabine NWR since 1949 (Chabreck and Linscombe 1978, 1988, 1997; Chabreck et al. 1968, Linscombe and Chabreck no date, O'Neil 1949, Sasser et al. 2008). Before the freshwater impoundments were constructed during the 1950s, most of the refuge was intermediate marsh, with some brackish marsh along the margins of Sabine and Calcasieu Lakes. After the impoundment in Unit 3 was constructed, that unit was maintained as a freshwater area which supported fresh marsh until Hurricane Rita damaged the water control structures in 2005, leading to saltwater intrusion into the unit and conversion of part of the unit to intermediate marsh by 2007. Units 1A and 1B converted slowly to fresh marsh from 1968 to 2001, and then shifted back to intermediate marsh after Hurricane Rita.

Figure 8. Distribution of marsh vegetation from 1949 to 2007 on Sabine NWR



D-6: CURRENT HABITAT CONDITIONS

For each habitat type, a general description is provided. Vegetation mapping has not been conducted on Sabine NWR, but likely correspondence to International Vegetation Classification (IVC) system is documented below, based on descriptions provided by NatureServe (2012).

Salt Marsh

Salt, or saline, marsh is found where regular flooding with saline water (>16 ppt) occurs and water is shallow enough to allow emergent graminoid vegetation to grow. On the Louisiana Gulf coast, salt marsh is usually dominated by *Spartina alterniflora*, with varying amounts of *S. patens*, *Distichlis spicata*, *Juncus roemerianus*, and *Batis maritima* (Lester et al. 2005). Salt marsh is botanically less diverse than less saline marsh environments, but it is highly productive and supports a diverse and economically important suite of marine organisms including shellfish, finfish, birds, and mammals. Salt marsh is currently found on the eastern end of Sabine NWR, in West Cove Units 1, 1A, and 2, adjacent to Calcasieu Lake and the Calcasieu Ship Channel.

IVC: Salt marsh on Sabine NWR probably maps to *Spartina alterniflora* – *Juncus roemerianus* – *Distichlis spicata* Louisianian Zone Salt Tidal Herbaceous Vegetation (CEGL004190). Also possible, inland from the previous association, is *Spartina alterniflora* - *Distichlis spicata* - *Spartina patens* Mesohaline Tidal Herbaceous Vegetation (CEGL002230) (NatureServe 2012).

Brackish Marsh

Brackish marsh is wetland dominated by emergent, salt-tolerant herbaceous vegetation where salinities average about 8 ppt (Lester et al. 2005) and may range as high as 20 ppt. Brackish marsh is usually found between intermediate marsh and saline marsh or adjacent to brackish open water systems (estuaries). Brackish marshes generally have lower vascular plant diversity than intermediate or fresh marshes. In Louisiana, these marshes are usually dominated by *Spartina patens*, with varying densities of *Distichlis spicata*, *Schoenoplectus olneyi*, *S. robustus*, *Eleocharis parvula*, *Paspalum vaginatum*, *Juncus roemerianus*, *Bacopa monnieri*, *Spartina alterniflora*, and *S. cynosuroides* (Lester et al. 2005). Areas of open water alternate with emergent vegetation and provide drainage and water exchange. Submerged aquatic vegetation in open water areas is usually dominated by *Ruppia maritima*.

On Sabine NWR, brackish marsh covers portions of the shoreline area along Sabine Lake and is present on the eastern end of the refuge in the West Cove units east of the highway, as well as in the central portion of Unit 1. Newly restored sections of Unit 1 quickly become colonized by *Spartina alterniflora* in areas where brackish water predominates.

IVC: Most of the brackish marsh on Sabine NWR is probably *Spartina patens* – *Schoenoplectus (americanus, pungens)* – (*Distichlis spicata*) Herbaceous Vegetation (CEGL004755) (NatureServe 2012).

Intermediate Marsh

Intermediate, or oligohaline marsh, generally lies between fresh marsh and brackish marsh. Salinities in this habitat range between 3 and 10 ppt, and plant diversity also is intermediate between that of fresh and brackish marsh (Lester et al. 2005). Many of the same species which are found in fresh and brackish marsh are found in this habitat as well, except that the least salt-tolerant species of fresh marsh are absent (i.e. *Panicum hemitomon*, *Typha* spp., *Nymphaea odorata*, and the exotics

Salvinia spp. and *Eichhornia crassipes*). Dominant emergent plant species in intermediate marsh include *Spartina patens*, *Phragmites australis*, *Sagittaria lancifolia*, *Bacopa monnieri*, *Eleocharis* spp., *Schoenoplectus olneyi*, *S. californicus*, and *S. americanus*. Other plant species found there include *Vigna luteola*, *Paspalum vaginatum*, *Panicum virgatum*, *Leptochloa fascicularis*, *Pluchea camphorata*, *Echinochloa walteri*, *Cyperus odoratus*, *Najas guadalupensis*, *Spartina cynosuroides*, and *Spartina spartinae* (LNHP 2009). *Alternanthera philoxeroides* is a common exotic invader in this habitat type.

Sabine NWR supports large areas of intermediate marsh in the western half of the refuge (Units 5, 6, and 7), as well as areas of Units 1 and 2. This type of marsh is decreasing statewide due to saltwater intrusion, which converts it to brackish marsh.

IVC: Oligohaline marshes on Sabine NWR, and in the Chenier Plain in general, mostly map to *Spartina patens* – *Typha* spp. Chenier Plain Oligohaline Herbaceous Vegetation (CEGL007887) (NatureServe 2012).

Fresh Marsh

Fresh marsh has the highest plant diversity of all the marsh types, and soil organic matter levels are generally higher than those in more saline marshes. This type of marsh is usually found closest to upland or freshwater bodies, and on the coast is maintained by constant flow of freshwater. Salinity averages about 0.5 ppt, and may range from 0 to 2 ppt. Emergent vascular plant species commonly associated with fresh marsh in Louisiana include *Panicum hemitomon*, *Eleocharis* spp., *Sagittaria lancifolia*, *Spartina patens*, *Phragmites australis*, *Bacopa monnieri*, *Cyperus odoratus*, *Pontederia cordata*, *Typha* spp., *Zizaniopsis miliacea*, *Vigna luteola*, *Hydrocotyle* spp., and *Peltandra virginica*. Submerged and floating aquatic plants include *Lemna minor*, *Myriophyllum* spp., *Nymphaea odorata*, and *Utricularia* spp. Invasive exotic plants found in this system include *Alternanthera philoxeroides*, *Eichhornia crassipes*, *Salvinia* spp., and old-world ecotypes of *Phragmites australis* (Lester et al. 2005, Swearingen and Saltonstall 2010).

On Sabine NWR, fresh marsh has historically been maintained in (impounded) Units 1A, 1B, and 3, and those units still contain the refuge's main examples of this habitat type. Saltwater intrusion from landscape alterations, sea level rise, and subsidence has taken a severe toll on fresh marsh in Louisiana. Estimated acreage losses, since European settlement, range up to 50 percent (Lester et al. 2005). On the refuge, saltwater intrusion has reduced the area of fresh marsh inside the impoundments.

IVC: Maidencane-dominated marsh areas on Sabine NWR are most likely *Panicum hemitomon* Semipermanently Flooded Herbaceous Vegetation (CEGL004665). Other possible associations include *Sagittaria lancifolia* Herbaceous Vegetation (CEGL004262) and *Schoenoplectus americanus* – (*Spartina patens*) – *Typha* spp. Herbaceous Vegetation (CEGL008476) (NatureServe 2012).

Terrestrial Habitats (Levees and Spoil Banks, Coastal Prairie)

Levees and Spoil Banks

Vegetation on artificial uplands on Sabine NWR generally consists of ruderal communities with many exotics. Typical woody species here include *Celtis laevigata*, *Diospyros virginiana*, *Morella cerifera*, *Salix nigra*, *Melia azedarach*, and *Triadica sebifera*. Herbaceous cover is generally dominated by exotic grasses such as *Cynodon dactylon* and *Paspalum urvillei*.

Coastal Prairie

Small, insular patches of natural upland, the largest of which is Marceaux Island, support remnant coastal prairie communities on Sabine NWR. These areas are dominated by native, warm-season grasses and support a diverse prairie community (plant list presented in Appendix D).

IVC: Prairie remnant vegetation has not been mapped on Sabine NWR, but these areas probably fall within the Texas-Louisiana Coastal Prairie Ecological System (CES203.550).

D-7: CHANGES IN HABITAT CONDITIONS

The unbroken expanse of natural habitats that greeted 18th Century European explorers in southwestern Louisiana is now gone, replaced by a patchwork of land uses which have displaced the natural habitats that preceded them, fragmented the landscape, and irreversibly changed ecosystem processes which formerly dominated the systems, especially hydrology and fire. Of the 9 million acres of coastal prairie which covered southeastern Texas and southwestern Louisiana at the time of European settlement, only about 1 percent remains (White et al. 1998). Much of that is in poor condition due to fragmentation, fire exclusion, and invasive species (Teague 2003). A total of 1,349 square miles (3494 km²) of coastal wetlands, including fresh, brackish, and salt marshes, have been lost since the 1950s along the Louisiana coast due in part to human activity including dredging, oil and gas exploration, modification of hydrology for agricultural and other purposes, and the influence of exotic species, particularly nutria (Barras et al. 2008). The projected losses through 2050 total 500 square miles, with current restoration efforts being taken into account (Barras et al. 2003). Anthropogenic ecosystem changes on the Chenier Plain fall into four broad categories, each of which will be discussed below: vegetation conversion, introduction of exotic species, alteration of hydrology, and alteration of fire regime.

Vegetation conversion

Humans have been converting natural systems to agricultural systems for thousands of years, and long-term vegetation change is an unavoidable consequence of agricultural development. Upland portions of the Chenier Plain in southwestern Louisiana have been under cultivation for rice and other grains, and soybeans, for many decades. More recently, crawfish farming has been added to this mix. Agricultural landscapes function as habitat for many wildlife species, but others, notably grassland birds, have declined as the coastal prairie has been reduced to remnant patches (Allain et al. 2000). Isolated patches of prairie found on Sabine NWR were probably too small and inaccessible for agricultural conversion, and so they persist, providing valuable habitat as well as reference sites to guide prairie restoration projects.

Exotic species

Thousands of exotic species of all taxa have been introduced, both purposely and by accident, to North America since European settlement. Of these, only a small fraction is considered invasive or otherwise ecologically detrimental. However, invasive exotics have the potential to do great damage to ecosystems which have not had time to adjust to their presence. Exotic species often arrive without the natural parasites, diseases, or predators which kept them in check in their native environments, a circumstance which can give them a competitive advantage over native species, especially if no native species are preadapted to assume those roles. Further, native species often have inadequate natural defenses against predatory, parasitic, or competitive strategies employed by introduced species. Anthropogenic landscape changes can interact with exotic species to compound

the damage. In North America, the introduction of exotic fungal tree pathogens like *Ophiostoma novo-ulmi*, the pathogen which causes the most virulent form of Dutch elm disease, and *Cryphonectria parasitica*, the causal agent of chestnut blight, and insects like the hemlock woolly adelgid (*Adelges tsugae*) provide particularly stark examples of the destructive force of exotics. In some cases, anthropogenic landscape changes can also transform native species into undesirable “invasives” in their native range, as is the case with brown-headed cowbirds (*Molothrus ater*) in much of North America.

On Sabine NWR, a number of invasive exotic species have the potential to cause damage on a scale which triggers a management response. These are listed and briefly described in Table 3.

Table 3. Exotic and/or invasive species which pose management challenges on Sabine NWR

Common Names	Scientific Name (Family)	Origin/ Status	Description	Management Challenges
Feral swine, hog, pig	<i>Sus scrofa</i> (Suidae)	Eurasia/exotic	Feral livestock	Land disturbance, predation of ground-nesting birds, disease vector
Nutria, coypu	<i>Myocastor coypus</i> (Myocastoridae)	South America/ exotic	Rodent introduced as furbearer	Destruction of marsh vegetation, burrowing in levees and marsh soils.
Chinese tallowtree, popcorn tree	<i>Triadica sebifera</i> (Euphorbiaceae)	China/exotic	Small tree introduced as an oilseed crop from Asia	Prolific woody plant with allelopathic properties; replaces native vegetation with monospecific stands (Texas Invasives 2010)
Saltcedar	<i>Tamarix spp.</i> (Tamaricaceae)	Mediterranean region/exotic	Small trees introduced as ornamentals; taxonomy of the various species is uncertain.	Quickly forms dense riparian stands which shade out native vegetation; little value for wildlife. Very high transpiration rates deplete soil moisture and reduce flow in streams (Texas Invasives 2010, Lovich 2006)

Common Names	Scientific Name (Family)	Origin/ Status	Description	Management Challenges
Giant salvinia/ common salvinia	<i>Salvinia molesta</i> ; <i>Salvinia minima</i> (Salviniaceae)	South America/ exotic	Free-floating aquatic fern originally introduced as an ornamental	Covers the surface of freshwater and shades out native aquatic plants; causes low dissolved O ₂ levels in water column (Texas Invasives 2010)
Water hyacinth	<i>Eichhornia crassipes</i> (Pontederiaceae)	South America/ exotic	Free-floating flowering plant introduced as an ornamental	Covers the surface of fresh water and shades out native aquatic plants; causes low dissolved O ₂ levels in water column (Texas Invasives 2010, Lazarine no date, Fassett 1960)
Phragmites, common reed, Roseau cane	<i>Phragmites australis</i> (Poaceae)	Cosmopolitan species with native and introduced varieties	Robust perennial wetland grass; probably introduced by accident through commerce (Van Fleet and Juanes 2009)	Eurasian haplotypes form monospecific stands and crowd out species with greater wildlife habitat value
Maidencane	<i>Panicum hemitomon</i> (Poaceae)	Native to eastern and southern US	Perennial wetland grass restricted to freshwater marshes; intolerant of salinities greater than 7-12 ppt.	Although maidencane has value for wildlife, under some conditions it can outcompete other plants more valuable for waterfowl habitat (Walsh 1994)

Hydrologic alteration

Alteration of hydrology in the Chenier Plain has been undertaken for a variety of purposes, including facilitating transportation, providing freshwater for irrigation, conducting oil and gas extraction, preventing saltwater intrusion, protecting infrastructure from hurricanes, and promoting drainage of agricultural and urban lands. Landscapes change, often in unintended ways, when their hydrology is altered. For example, drainage of organic soils can result in severe shrinkage and subsidence (Soil Conservation Service 1995), and can make the soil vulnerable to ground fires which consume the organic portions of the soil profile. Artificially extending the flood period on seasonally flooded wetlands will result in vegetation changes, which may or may not be desirable from a management standpoint.

Hydrology has been altered on major portions of Sabine NWR. A large portion of the refuge has been in freshwater impoundments for several decades, in which water levels were maintained artificially high through the use of levees and water control structures. Other structures, including levees, water control structures, and terraces, have been constructed in an effort to restore marsh and slow the intrusion of saltwater into formerly freshwater systems. Off-site modifications of hydrology, most notably the construction of canals and waterways for navigation and oil and gas exploration, have resulted in increased levels of salinity on the refuge. In 2011, a harbor-deepening project was planned that would probably result in higher salinities in Sabine Lake (U.S. Fish and Wildlife Service 2010b). Further, interbasin transfer of up to 500,000-acre-feet of water from the Sabine basin (Toledo Bend Reservoir) to the Dallas-Fort Worth metropolitan area is planned (Region C Water Planning Group 2010). Removal of freshwater from the basin may cause higher salinities in Sabine Lake, which would in turn result in higher salinities on Sabine NWR. Taken together, the hydrological alterations on and around Sabine NWR are extensive and, at least in the short term, irreversible. Management of the refuge must proceed within the context of this fact, and managers must recognize that to fulfill the refuge purposes, active management of water will be necessary for the foreseeable future.

Alteration of Fire Regime

Alteration of fire regimes is probably one of the first ways that humans changed their environment, and most human-influenced landscapes exhibit some degree of change due to modification of the fire regime. As in most of North America, early human occupants probably decreased the fire return interval on the Chenier Plain, and may have modified seasonality and other aspects, in order to change the landscape to their liking (Pyne 1982, 1995). European settlers had a much different relationship with fire, along with more intensive agricultural practices which tended to break the landscape into smaller units and decrease natural fire frequency by reducing the area affected by each individual fire. Currently, reduction in fire frequency is a major threat to many ecosystems across North America, and coastal marshes and prairies along the Gulf coast are no exception. Lester et al. (2005) list fire suppression as a “very high” threat to coastal prairie systems in Louisiana, along with development, invasive species, land use conversion, and incompatible grazing practices.

D-8: CLIMATE CHANGE

The southeastern United States may be one of the most vulnerable regions in the United States to climate change (Smith 2004; Karl et al. 2009). It faces risks from climate change because it has a long and low-lying coastline (41 percent of the coterminous U.S. coastline) (NOAA 1975) that is exposed to sea level rise and hurricanes; it is already relatively warm and thus will not, for the most part, benefit from more heat; it will be exposed to more risks of disease; and it has high biodiversity.

In addition to being home to almost 60 million people, the Southeast has over 400,000 farms on almost 80 million acres (USDA 2008), over 127 million acres of timberland (USFS 2010), 33 percent of U.S. (coterminous) estuaries (NOAA 1990), and nearly 30 percent of all U.S. wetlands (Dahl 1990). For these and other reasons, the region faces many risks from climate change.

Temperature Increases

Since 1970, the southeastern United States has experienced about a 2°F rise in temperature, with the greatest seasonal increase occurring in the winter (Karl et al. 2009). Climate models project warming to occur in the Southeast, with different emissions scenarios predicting that temperatures could rise by about 4.5°F on average by the 2080s. The greatest temperature increases are projected to occur in the summer (Karl et al. 2009).

These temperature increases are having, or are projected to have, a number of effects of interest to refuge managers including:

- The number of freezing days for most of the Southeast has declined by four to seven days per year since the mid-1970s (Karl et al. 2009).
- Higher air temperatures will increase water temperatures, which will likely lead to a decrease in dissolved oxygen (DO) in water bodies. Hypoxic conditions (i.e., when DO reaches a minimum threshold that no longer allows aquatic species to survive) are more likely to occur.
- Higher water temperatures will likely lead to more thermal stratification in lakes and reservoirs in the Southeast, resulting in less oxygen mixing.
- Higher water temperatures will likely lead to more algae growth.
- Increased temperatures result in higher pathogen replication, persistence, survival, and transmission (CDC 2009).

Changes in Precipitation

Changes in amount and timing of precipitation have already been documented, and more are predicted by climate models. The average fall precipitation in the Southeast has increased by 30 percent since the early 1900s and summer and winter precipitation declined by nearly 10 percent in the eastern part of the region (Karl et al. 2009). When averaged, climate change models project that southern states will tend to have a decrease in precipitation by 2070. Increases in fall precipitation will be more than offset by decreases in precipitation over the rest of the year.

In the Southeast, there has been an increase in heavy downpours in many parts of the region (Karl et al. 2009). These heavy precipitation events may lead to an increased chance of flooding. At the same time, certain areas may experience an increased frequency of drought where precipitation has declined during the spring, summer, and winter months. Higher temperatures will also increase the likelihood of droughts (Karl et al. 2008). Expected impacts include increased risk of wildfires, changes in the distribution and types of insects, and possibly some increased salinities.

Karl et al. (2009) reported that there has been an increasing trend of summer drought in the region over the period 1958-2007. Decreases in overall summer precipitation will likely cause reduced water flows, which will contribute to warmer water temperatures and further stress water quality. This is particularly important in the context of seasonal droughts. During low-flow periods, nutrients will become concentrated and flush out of systems more slowly.

Changes in Storm Intensity or Frequency

Increases in the number of extreme storm events (tropical and inland) will likely result in more runoff of nutrients; pathogens from human and animal waste; sediment from cropland and animal feeding operations; pesticides from combined sewer overflows and nonpoint source runoff; and toxins from industrial, commercial, and other sources. Increased nutrient loading can lead to more algae and plant growth, which results in lower DO levels. Greater runoff can also result in greater pathogen impairments (i.e., designation of a water body as impaired under the Clean Water Act due to the presence of threshold levels of indicator bacteria) (U.S. EPA 2009b).

Changes in Sea Level

Assuming that average sea levels rise at least 2 feet by 2100 (Intergovernmental Panel on Climate Change 2007), the Southeast will likely see an increase in the extent of storm surge, which could easily be the most costly consequence of climate change (Karl et al. 2009). Hurricane intensity is also projected to increase, which will likely increase the size of storm surges (Knutson and Tuleya 2004).

Other impacts of sea level rise include increased risks of erosion, storm surge damage, and flooding for coastal communities, especially in the Southeast (Emanuel 2005, Karl et al. 2009). Rising sea levels will also convert wetlands to open water, exacerbate coastal flooding, and increase the salinity of estuaries and freshwater aquifers (Karl et al. 2009).

Ecological Effects of Climate Change

Currently, climate change is not the most important driver of changes in biodiversity; however, it could be the largest driver by the end of the 21st century (Millennium Ecosystem Assessment 2005). Even so, there have already been measurable changes in global biodiversity due to climate change, particularly with regard to changes in species distributions, population sizes, timing of reproduction or migration events, and increases in the frequency of pest and disease outbreaks (Millennium Ecosystem Assessment 2005). In the United States, climate change has already impacted terrestrial ecosystems by changing the timing of growing season length, phenology, primary production, and species distributions and diversity (Janetos et al. 2008). Interestingly, there is some evidence that nonnative and particularly nonnative invasive, plant species are more phenologically plastic in the face of climate change, and therefore may become more competitive over time relative to native plants (Willis et al. 2010). However, crop plants (though mostly exotic to the southeastern United States) are apparently not positioned to benefit from climate change; crop losses, particularly in the southeastern United States, are projected to occur with climate change as well (NAST 2001).

Rising sea levels will increase the vulnerability of spawning and nursery habitat through inundation of wetlands and coastal marshes and saltwater intrusion, leading to a loss of wetland-dependent coastal fish and shellfish (Karl et al. 2009). Increasing temperatures will cause certain species of fish to shift their geographical range (Janetos et al. 2008). Increasing frequency and intensity of storms may result in increased mortality of early life states, altered transport of larval fish, and altered recruitment (Connelly et al. 2007). Increased coastal erosion resulting from sea level rise leads to loss of barrier

islands and wetlands (Intergovernmental Panel on Climate Change 2007, U.S. EPA 2009a). Increased sea level, storm surge, and storm intensity will likely inundate or destroy wetland and barrier island habitat and convert marshlands to open water and forests to marshland.

Sea level rise and increased hurricane intensity will likely cause coastlines to experience periods of erosion and accretion, depending on dynamic natural and anthropogenic conditions. Coastal erosion is also affected by anthropogenic factors including activities like dredging, coastal engineering, land development, and construction of sea walls and dams. Barrier islands and wetlands, features of some coastlines, are vulnerable to changes in sea level, and may even have thresholds that, when crossed, could lead to irreparable damage (Nicholls et al. 2007).

Coastal wetlands (marshes and mangroves) provide many ecosystem services for coastal areas. For example, they reduce peak flood flows by delaying and storing floodwaters; protect water quality; maintain resilience of natural coastal defenses through alluvial plain accumulation; act as a storm surge buffer; provide nurseries for coastal fisheries; and protect freshwater from saltwater intrusion. The interactions of climate change, land subsidence, coastal development, and shore stabilization practices have contributed to the decline of coastal wetlands. Titus et al. (2009) conclude that climate change has caused, and will continue to cause, the loss of coastal wetlands.

D-9: HABITAT RESTORATION

In an attempt to stem and reverse the ongoing losses of coastal marsh habitat on the Gulf coast due to factors described above, a number of direct and indirect marsh restoration strategies have been devised, including levee protection, the use of water control structures, addition of sediment either by diverting river flow or as dredge spoil, and construction of discontinuous levees known as terraces. Two of those strategies are being employed on Sabine NWR. First, terraces are being constructed in open-water areas of unimpounded marsh to slow the conversion of marsh to open water by reducing wave action and creating dead-water zones downwind of the terraces, where organic matter can accumulate and submerged aquatic plants can become established. The first terraces were “checkerboard” or square in shape, and were constructed in 1990 in ponds in West Cove Unit 2 (Figure 9). Later terraces (1997-2011) were constructed in a zigzag configuration on a general east-west orientation to take advantage of prevailing winds (Figure 10). As of 2010, 221,000 linear feet of terraces had been constructed in Units 5, 6, 7, and West Cove 2.

Second, beneficial use of dredge spoil has been used in Unit 1 to re-create marsh where subsidence and erosion had left open water. Calcasieu Ship Channel, which is dredged on a 2-year cycle, is the source of the material. The Corps of Engineers, funded through CWPPRA Project CS-28, has constructed a 30-inch diameter pipeline along the northern property line of the refuge reaching from the ship channel to Unit 1, through which material can be pumped. The sediment is placed within levees for containment, but the levees can be breached to expand the area affected by the sediment and create a more natural marsh edge. So far, dredge material has been used to re-create 673 acres of marsh habitat in three areas of Unit 1 where open water existed before (Figures 11 and 12). The sediment functions as mudflat habitat for 1 or 2 years (Figure 13), after which it becomes naturally vegetated, mostly by *Spartina alterniflora*. The refuge plans to continue this practice as long as material is available and moving it to restoration sites is feasible. Presently, two more areas totaling 449 acres are permitted under Project CS-28 for beneficial dredge material application. Five more areas totaling 1,417 acres have been proposed. Restored marsh and areas planned for future marsh restoration by beneficial application of dredge material are presented in Figure 14. If all of the areas shown in Figure 14 are eventually restored, total restored marsh will be approximately 2,539 acres.

Figure 9. Checkerboard terraces in Sabine NWR Unit West Cove 2



Figure 10. Zig-zag terraces in Unit 6, Sabine NWR



Figure 11. Restored marsh created with beneficial dredge material on Sabine NWR



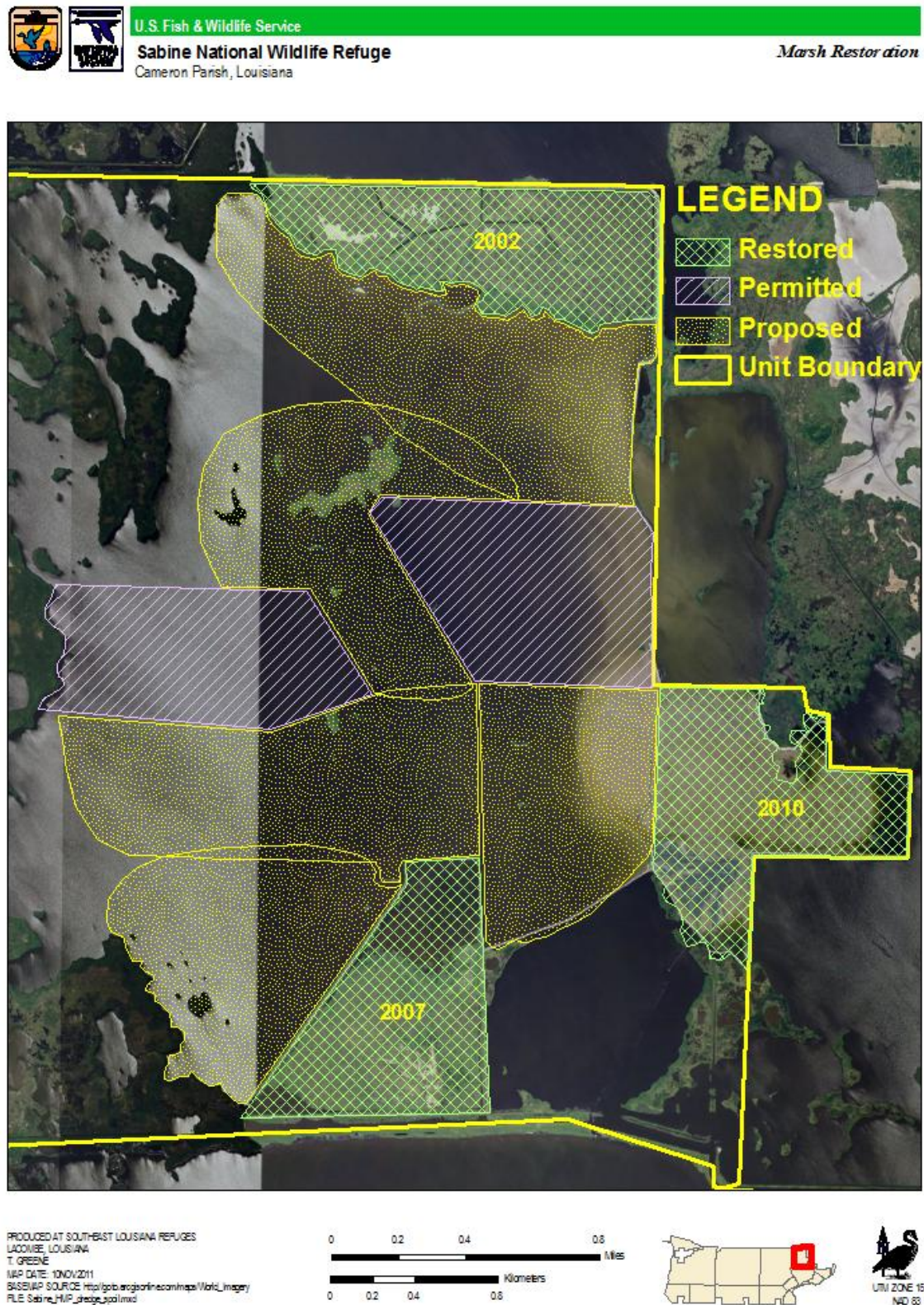
Figure 12. Restored marsh, naturally revegetated with *Spartina alterniflora* after 3 years, Sabine NWR; Photo: USFWS (2011)



Figure 13. Newly deposited beneficial dredge material on Sabine NWR (2007)



Figure 14. Restored (with completion date), permitted, and proposed areas for application of beneficial dredge material, Sabine NWR



III. Resources of Concern

A. IDENTIFICATION OF REFUGE RESOURCES OF CONCERN

Priorities associated with wildlife and habitat management for the Refuge System are determined through directives, policies, and legal mandates. Resources of concern include species, species groups, and/or communities that support refuge purposes, as well as Service trust resource responsibilities (including threatened and endangered species and migratory birds). Resources of concern are also native species and natural, functional communities such as those found under historic conditions that are to be maintained and, where appropriate, restored on a refuge [601 FW 3.10B(1)].

Resources of concern for Sabine NWR were selected after taking into account the conservation needs identified within international, national, regional, or ecosystems goals/plans; state fish and wildlife conservation plans; recovery plans for threatened and endangered species; and previously approved refuge resource management plans as identified in the Comprehensive Conservation Planning Process policy [602 FW 3.4C(1)(E)], as well as Chapter I of this HMP. The species/communities selected as resources of concern from these plans support the following Refuge System mandates:

- Support refuge purposes and the Refuge System mission;
- Conserve biological integrity, diversity, and environmental health;
- Give special consideration to rare, declining, or unique natural communities; species; and ecological processes within the refuge boundary;
- Fulfill Service trust resource responsibilities.

Resources of concern identified for Sabine NWR include:

- Waterfowl (including wintering ducks and geese and mottled ducks)
- Marsh Birds
- Fisheries

In addition, a number of other species with complementary habitat needs are identified. These are species which, while not the target of management actions, are trust species which are thought to benefit from habitat management actions taken on behalf of the species of concern.

A-1: WATERFOWL

Sabine NWR provides abundant, high-quality habitat for wintering waterfowl and for the year-round resident mottled duck. Winter habitat requirements for mottled ducks are similar to those for their migratory congeners; however, mottled ducks also breed on the refuge and have unique habitat requirements during the spring and summer. Providing habitat for all of these species fulfills the purpose for which the refuge was established in 1937 "...as a refuge and breeding ground for migratory birds and other wildlife."

Wintering Waterfowl

Coastal Louisiana is one of the most important waterfowl wintering areas in North America. Sabine NWR's marshes and impoundments support a diversity of plants favorable for waterfowl, as well as provide loafing and roosting sites to many species of ducks and geese.

Sabine NWR is located in the Mississippi and Central Flyways, which are critical for migrating ducks and geese in North America (Reinecke et al. 1989). The refuge attracts tens of thousands of blue-winged teal, cinnamon teal, green-winged teal, gadwall (*Anas strepera*), northern shovelers, ring-necked ducks (*Aythya collaris*), northern pintail, and several species of geese during the winter. A complete list of waterfowl known from Sabine NWR is included in Appendix D. Management actions envisioned by this plan would continue to support, restore, and maintain the freshwater, intermediate, and brackish marshes on Sabine NWR. Migratory waterfowl use the refuge as a feeding, loafing, and roosting site. Protecting and managing the hydrology of the refuge will conserve important wintering habitat.

Because of historic and ongoing habitat losses due to oil and gas exploration and extraction, hydrologic alteration, and climate change, suitable habitat for wintering waterfowl has decreased over the past two centuries, leading to a decrease in waterfowl populations in North America (Batt et al. 1992). When large, unbroken expanses of wetlands and coastal prairies were available for use by waterfowl, the entire system was more resilient in the face of natural disturbances such as fire, drought, and tropical storms. In the current, anthropogenically modified landscape, habitat loss, habitat fragmentation, the introduction of exotic plant and animal species, and disruption of natural hydrological and pyric processes mean that remaining habitat, in order to function in the larger context of the continent-wide ecosystem, must be actively managed. Small fragments of habitat are less resilient to disturbances and without management of vegetation, hydrology, fire, and animal populations will change over time so that they no longer serve as high-quality habitat for waterfowl or other desirable species.

Mottled Duck

The mottled duck is a year-round resident in coastal marshes along the western Gulf coast (western subspecies, Texas and Louisiana; *Anas fulvigula maculosa*) and in the wetlands of Florida (eastern subspecies, *Anas fulvigula fulvigula*) (Rorabaugh and Zwank 1983). A report by the GCJV (a partnership between state and local wildlife agencies and nonprofit organizations) showed a dramatic and consistent downward trend in the western mottled duck population between 1966 and 2002. However, only in nearby Texas has the population declined; populations in Louisiana appear stable. Declining recruitment is the most likely source of the population decline (Wilson 2007). Wetland habitat drainage, declining rice farming, lead exposure, and increasing predator populations have also contributed to population declines (Wilson 2007).

Historically, flooded rice fields have provided important feeding and loafing habitat to mottled ducks in southwest Louisiana. However, rice farming has declined in recent years, restricting the amount of this artificial habitat which is available to waterfowl. On nearby Cameron Prairie NWR and Lacassine NWR, fields are being managed to provide this important habitat type. On Sabine NWR, which has no agricultural habitat, the large areas of impounded and unimpounded marsh provide important feeding and loafing habitat for mottled ducks. Mottled ducks depend on tall, dense, undisturbed stands of grass for nesting (Rorabaugh and Zwank 1983). Sabine NWR has the ability to provide important habitat for breeding mottled ducks and can contribute to the sustainability of the species.

A-2: MARSH BIRDS

A suite of marsh birds, including 9 species in the family Rallidae, as well as seaside sparrows (*Ammodramus maritimus*), Nelson's sparrow (*A. nelsoni*), pied-billed grebe, and least bittern, depend on the marsh habitats on Sabine NWR and are a resource for which the refuge was created in 1937. These birds, most of which are of at least moderate conservation concern due to threats and population declines (Hunter et al. 2006), were selected as a Resource of Concern because they serve as focal resources for the marsh habitat which composes most of the refuge, and their conservation is a priority for the Service. Marsh birds have ecological value as important elements of natural systems and perform valuable functions benefitting the natural balance in ecosystems as well as providing many benefits to humans (Kushlan et al. 2002).

Table 4. Marsh birds known from Sabine NWR with their conservation status (Hunter et al. 2006)

Species	Scientific Name	Tier ¹	Conservation Status (Action Level) ¹	Seasons of Occurrence on Sabine NWR ³			
Podocipedidae				Sp	S	F	W
Pied-billed Grebe²	<i>Podilymbus podiceps</i>	Concern	Management Attention	c	u	c	c
Rallidae							
Yellow Rail	<i>Coturnicops noveboracensis</i>	Concern	Management Attention	u	-	u	r
Black Rail	<i>Laterallus jamaicensis</i>	Concern	Immediate Management	-	-	-	r
Clapper Rail²	<i>Rallus longirostris</i>	Concern	Planning and Responsibility	c	c	c	c
King Rail	<i>Rallus elegans</i>	Concern	Immediate Management	c	c	c	c
Virginia Rail	<i>Rallus limicola</i>	Concern	Immediate Management	u	-	-	c
Sora	<i>Porzana carolina</i>	Additional Stewardship	Planning and Responsibility	u	-	u	c
Purple Gallinule²	<i>Porphyrio martinica</i>	Concern	Immediate Management	u	c	u	r
Common Moorhen²	<i>Gallinula chloropus</i>	Additional Local or Regional Interest	Planning and Responsibility	c	c	c	c

Species	Scientific Name	Tier ¹	Conservation Status (Action Level) ¹	Seasons of Occurrence on Sabine NWR ³			
American Coot	<i>Fulica americana</i>	Additional Local or Regional Interest	Management Attention	c	-	c	c
Ardeidae							
Least Bittern²		Concern	Management Attention	c	a	r	r
Emberizidae							
Nelson's Sharp-tailed Sparrow	<i>Ammodramus nelsoni</i>	[not ranked]	[not ranked]	u	-	-	u
Seaside Sparrow²	<i>Ammodramus maritimus</i>	[not ranked]	[not ranked]	a	a	a	a

¹ For more information, see Hunter et al. (2006).

² Breeds on refuge

³ a=abundant; c=common; u=uncommon; r=rare; e=erratic; o=occasional (US Fish and Wildlife Service 1992).

A-3: FISHERIES

Impounded freshwater marsh areas (Units 3, 1A, and 1B) on Sabine NWR were popular with anglers before the storms of 2005 and 2008. The refuge managed this resource by stocking and monitoring through surveys. Management objectives and strategies described in this document include the continued management of this resource through the newly replaced CS-23 water control structures. Many marine species of fin and shellfish, including some economically important species, utilize fresh, intermediate, and brackish marsh units in Sabine NWR. These species, which include white shrimp (*Litopenaeus setiferus*), brown shrimp (*Farfantepenaeus aztecus*), red drum (*Sciaenops ocellatus*), and Gulf menhaden (*Brevoortia petronus*), among many others, are dependent on these units to complete their life cycles (Benfield et al. no date). A more extensive, but by no means complete, list of marine organisms which use the refuge can be found in Appedix D. Maintaining high-quality habitat for these and other commercially and ecologically important marine species is a priority for the refuge.

A-4: SPECIES WITH COMPLEMENTARY HABITAT REQUIREMENTS

While habitat objectives and strategies will be established based primarily on the habitat needs of the Resources of Concern identified above, it is recognized that refuges can and should be managed through an SHC approach that includes species and groups that represent the intricacy and diversity of the ecosystem at a landscape scale. The waterbird species listed in Table 5 fit the normal

definition of “Trust Species” [16 U.S.C. 3772 (1)], (Title 16. Conservation, Chapter 57B, Partners for Fish and Wildlife), and have habitat needs similar to those of the Resources of Concern, and are expected to benefit from management designed to meet the needs of the Resources of Concern.

Table 5. Waterbirds which use the open water, marsh, and mudflat habitats of Sabine NWR and which will benefit from habitat management actions detailed in this HMP

Family/Species	Habitat			Seasons of Occurrence ¹			
	Marsh	Mud flats	Open Water	Sp	S	F	W
BIRDS OF OPEN WATER HABITATS (ON SNWR)							
Gaviidae							
Common Loon			x	o	-	o	u
Podicipedidae							
Horned Grebe			x	o	-	o	o
Eared Grebe			x	u	-	u	u
Pelecanidae							
American White Pelican			x	c	o	c	c
Phalacrocoracidae							
Double-crested Cormorant			x	c	-	c	c
Neotropic Cormorant ²			x	c	c	c	c
Anhingidae							
Anhinga			x	-	o	-	o
Fregatidae							
Magnificent Frigatebird			x	-	r	r	-
Laridae							
Laughing Gull			x	c	c	c	c
Franklin's Gull			x	r	-	r	-
Bonaparte's Gull			x	-	-	r	u
Ring-billed Gull			x	u	-	u	c

Family/Species	Habitat			Seasons of Occurrence ¹			
	Marsh	Mud flats	Open Water	Sp	S	F	W
Herring Gull			x	u	-	u	c
Gull-billed Tern			x	u	u	u	u
Caspian Tern			x	u	u	u	u
Royal Tern			x	u	u	u	u
Common Tern			x	-	-	-	u
Forster's Tern			x	c	c	c	c
Least Tern			x	o	u	o	-
Black Tern			x	a	u	a	-
Black Skimmer			x	c	c	c	c
COLONIAL WATERBIRDS							
Ardeidae							
American Bittern	x			u	-	u	c
Great Blue Heron ²	x		x	c	c	c	c
Great Egret ²	x		x	c	c	c	c
Snowy Egret ²	x		x	c	c	c	c
Little Blue Heron	x		x	c	c	c	c
Tricolored Heron ²	x		x	c	c	c	c
Reddish Egret	x		x	r	r	r	r
Cattle Egret	x			c	c	u	u
Green Heron ²	x		x	a	a	c	o
Black-crowned Night-Heron	x		x	u	u	u	u
Yellow-crowned Night-Heron	x		x	o	u	o	r

Family/Species	Habitat			Seasons of Occurrence ¹			
	Marsh	Mud flats	Open Water	Sp	S	F	W
Threshkiornithidae							
Glossy Ibis	x	x		o	o	o	o
White Ibis ²	x	x		u	c	c	c
White-faced Ibis ²	x	x		c	c	c	c
Roseate Spoonbill ²	x	x	x	u	u	u	u
Ciconiidae							
Wood Stork	x	x	x	-	u	o	-
SHOREBIRDS							
Charadriidae							
Black-bellied Plover		x		c	-	c	c
American Golden Plover		x		r	-	r	-
Wilson's Plover		x		-	o	-	-
Semipalmated Plover		x		u	-	u	-
Killdeer ²		x		c	c	c	c
Recurvirostridae							
Black-necked Stilt ²		x		c	c	c	r
American Avocet		x		-	-	o	o
Scolopacidae							
Greater Yellowlegs		x		a	-	a	-
Lesser Yellowlegs		x		a	-	a	-
Solitary Sandpiper		x		u	-	u	-
Willet		x		c	c	c	c
Spotted Sandpiper		x		c	-	c	u

Family/Species	Habitat			Seasons of Occurrence ¹			
	Marsh	Mud flats	Open Water	Sp	S	F	W
Upland Sandpiper		x		r	-	r	-
Whimbrel		x		u	-	r	-
Long-billed Curlew		x		u	-	u	u
Marbled Godwit		x		o	-	o	-
Ruddy Turnstone		x		u	-	u	-
Red Knot		x		r	-	r	-
Sanderling		x		c	-	u	u
Semipalmated Sandpiper		x		a	-	a	-
Western Sandpiper		x		u	-	u	c
Least Sandpiper		x		c	-	c	c
White-rumped Sandpiper		x		c	-	-	-
Pectoral Sandpiper		x		u	-	u	-
Dunlin		x		c	-	c	c
Stilt Sandpiper		x		u	-	o	-
Short-billed Dowitcher		x		u	-	u	u
Long-billed Dowitcher		x		c	-	c	c
Common Snipe		x		c	-	c	a
American Woodcock		x		r	-	r	r

¹ a=abundant; c=common; u=uncommon; r=rare; e=erratic; o=occasional (US Fish and Wildlife Service 1992).

² Breeds on refuge

B. HABITAT REQUIREMENTS OF RESOURCES OF CONCERN

B-1: WATERFOWL

Wintering Waterfowl

North American waterfowl use a variety of habitats during different times of the year to meet their survival requirements. Migratory species travel thousands of miles to reach those habitats, while resident species may meet all their habitat requirements within a few dozen miles. Habitat quantity, quality, and availability determine the size and health of waterfowl populations. Therefore, waterfowl managers manage waterfowl by manipulating habitat quantity, quality, and timing of availability. Sustaining viable and harvestable populations of waterfowl depends on conservation and management of habitats throughout the flyways of North America. Wintering dabbling ducks use a diversity of wetland habitats including flooded cropland, flooded fallow cropland managed as “moist-soil” areas, natural wetlands, and refuge (i.e., sanctuary) (Reinecke et al. 1989). Although wintering waterfowl make good use of flooded cropland and moist-soil areas, these types of habitat are not provided on Sabine NWR; therefore, they will not be described in detail in this chapter.

Natural wetland habitats that wintering waterfowl, including mallards, gadwall, teal, American wigeon, shovelers, and geese, have used historically in southwest Louisiana are fresh, intermediate, brackish, and saline marshes. Optimum marsh habitat for these birds is approximately 50 percent emergent vegetation and 50 percent water, dispersed in a mosaic pattern with the largest edge effect possible. These natural wetlands are critical foraging and resting habitats. Marshes are rich in high-energy natural plant foods (grass and sedge seeds, roots, tubers) and aquatic invertebrates (Kaminski et al. 2003; Heitmeyer 1988, 2006). Wintering waterfowl satisfied their nutritional and other physiological needs in these wetlands before conversion to agriculture in southwest Louisiana.

Sanctuary, or protection from human, predator, and mechanical disturbance, is essential so that wintering waterfowl can gain weight in preparation for the spring migration and breeding season, while undergoing energy intensive physiological processes such as the prebasic molt (Reinecke et al. 1989; Strickland et al. 2009). Disturbance can interrupt resting and feeding bouts resulting in a loss of energy and lowering body weight (Henry 1980; Heitmeyer and Raveling 1988; Kahl 1991). Paulus (1984b), working in Louisiana, found that increased foraging time by gadwalls, which had no access to sanctuary, was insufficient to counteract the effects of disturbance.

Like ducks, wintering geese require food and foraging habitat, escape cover, and roosting habitat (Tesky 1993, Kaminski 1986). Forage for geese include: snails, cordgrass, widgeon grass (*Ruppia maritima*), bulrush, sedges, and spikerush. Wintering geese preferentially forage in rice fields in the fall after final harvest until availability of rice grains drops off due to consumption and/or decomposition (Hobaugh 1984, Kaminski 1986). Moist-soil units provide wild seed and green browse. Geese also forage on seeds of wetland graminoid plants (Hobaugh 1984, Kaminski 1986, Laskowski no date) and utilize green browse and invertebrates in impounded and unimpounded freshwater marsh. Tall marsh vegetation and vegetation on levees and spoil banks provide escape cover for geese, while moist-soil units and impoundments are most often used for roosting.

Geese require a source of grit for gizzard function. They prefer quartz-based grit over calcium carbonate-based grit. Artificial sources are very readily utilized in coastal Louisiana because of local scarcity of preferred natural grit sources. Maintaining artificial grit sites (piles of sand and pebbles) is therefore a benefit to geese. Snow geese are known to travel up to 36 miles from Sweet Lake and Thornwell, Louisiana, to use these sites (U.S. Fish and Wildlife Service 2006).

Mottled Duck

Unlike migratory ducks, mottled ducks spend their entire life cycles in wetland areas along the Gulf coast and must satisfy all of their habitat requirements from local resources. Their habitat requirements change throughout the breeding cycle; post-breeding mottled ducks use different habitats than do pairing, nesting, or brood-rearing individuals. Preferred habitats for mottled ducks include treeless marshes, prairies, and rice fields with the highest densities of nesting birds found in brackish to fresh coastal marsh (Rorabaugh and Zwank 1983). Adult mottled ducks are primarily vegetarians and feed in shallow water, with depth as an important variable for autumn habitat (Singleton 1953; White and James 1978). However, their diet may be highly varied and considerable animal mass may be consumed (Singleton 1953). Over the year, these birds use a succession of habitat types for different activities. During pair bonding in early winter, mottled ducks preferentially use small ponds within the coastal marsh for attracting mates and pairing (Haukos et al. 2010). Then, hens select nesting habitat which has quite different characteristics, and after hatching, they seek out brood habitat with yet another set of characteristics (Rorabaugh and Zwank 1983). Post-breeding habitat differs from all of the habitats used during the breeding season. Although all of these habitat types are found within healthy coastal marsh, it is important for managers to understand how specific habitat requirements change over the year. Each of these four habitat types will be discussed below.

Post-breeding/Wintering habitat

Mottled ducks are dabbling ducks that primarily feed (as adults) on plant materials in shallow (≤ 30 cm/1 ft.) water. They spend most of their time in or near emergent, graminoid marsh habitat. During the post-breeding molt, when they are flightless for a month, they prefer larger bodies of water with shallow beds of submerged aquatic vegetation and escape cover on the margins (Rorabaugh and Zwank 1983). They can also use areas that are devegetated by muskrats or geese, and subsequently flooded, during this time (Stutzenbaker 1979). Salinities in these habitats can vary from fresh to brackish or saline.

Pairing pond habitat

Some time in late fall or early winter, pair bonding begins for this species. Drakes occupy and defend small (0.02-0.15 ha/0.05-0.4 ac, ~ 1 m/3 ft. deep) ponds surrounded by marsh habitat (Haukos et al. 2010), and by December, 90 percent of them are paired (Paulus 1984a). In a recent study in southeast Texas, mottled ducks used ponds with salinities ranging from fresh to saline; however, they preferentially selected shallow, fresh ponds (≤ 2 ppt salinity) and ones that were surrounded by marsh vegetation that had been grazed recently. They avoided ponds surrounded by recently burned marsh vegetation (Haukos et al. 2010).

Nesting habitat

Mottled ducks begin nesting in February and nesting continues through August (Rorabaugh and Zwank 1983, Walters 2000). Nesting habitat in coastal marshes is characterized by tall, dense stands of grass located on elevated sites above high tide and generally within 150m/500 feet of water (Rorabaugh and Zwank 1983). They prefer a high land/water ratio for nesting habitat, and prefer prairie vegetation over marsh or woody cover (Walters 2000). They nest on the ground under bushes or near large clumps of graminoid plants such as bulrush (*Schoenoplectus* spp.) in or near the marsh (Terres 1980). Engeling (1950) and Singleton (1953) found nests on levees, road sites, and fallow rice fields with little grazing pressure in rice production areas. Mottled ducks use a variety of plant

species for nesting cover which may include clumps of cordgrass (*Spartina* spp.), saltgrass (*Distichlis spicata*), and false indigo (*Baptisia sphaerocarpa*) where grasses are sparse or short. Wet soil conditions with an abundance of rushes, bulrush, and cattails lower nesting habitat quality and dense shrub habitat is avoided entirely (Rorabaugh and Zwank 1983).

Brood habitat

Adequate brood habitat is essential for duckling survival and reproductive success. Contrary to requirements for nesting habitat, hens with newly hatched ducklings prefer a high water to land ratio (60:40), with emergent and shoreline vegetation that may be used as cover (Rorabaugh and Zwank 1983). Engeling (1950) found that in Texas coastal marshes brood rearing sites which were bordered by cordgrass, saltgrass, and bulrush were the most successful. Rorabaugh and Zwank (1983) recommend targeting marsh with 40 to 60 percent emergent vegetation and 40 to 60 percent open water. Flooded rice fields are also used as brood-rearing sites, but the quality of this habitat is disputed. Ducklings are less efficient feeders than adults, so hens will preferentially bring broods to areas of abundant food supply (Afton and Paulus 1992) and may travel several kilometers (1 km = 0.6 miles) from the nest to reach favorable brood-rearing habitat (Paulus 1984a). Invertebrates are especially important for young ducklings. Singleton (1953) and Stutzenbaker (1979) found that from hatching to 3 weeks 80 percent of the diet of broods consisted of insects, insect larvae, small fish, snails, and amphipods. Ducklings begin to shift from animal to plant-based foods after 4 weeks (Rorabaugh and Zwank 1983).

B-2: MARSH BIRDS

As for many other groups of birds, the variables that control habitat selection and quality are many and complex for marsh birds. At small scales, food availability, cover, nest material, protection from predators and weather, presence of open water, water depth, and type, height and density of vegetation, all influence habitat selection and use by these birds (Riffell et al. 2003, Osnas 2003, Lor and Malecki 2006, Johnson and Dinsmore 1986). On landscape scales, the area and distribution of suitable habitat patches is an important determinant in use by certain marsh birds, while others appear not to be affected by these variables (Brown and Dinsmore 1986, Benoit and Askins 2002, Fairbairn and Dinsmore 2001). A general understanding of these variables and how they influence habitat quality and avian species richness on the refuge is important for management decisions. Two habitat requirements are shared by most or all of the secretive marsh bird species which use Sabine NWR: the presence of emergent marsh vegetation, mostly graminoid, and the presence of open water in various proportions to the marsh cover. Specific requirements of the 11 species of (non-passerine) secretive marsh birds which breed or winter on Sabine NWR are presented in Table 7.

Seaside sparrow (*Ammodramus maritimus*) and its rarer congener, Nelson's sparrow (*A. nelsoni*) are members of a predominantly terrestrial group of birds that have evolved to exploit salt marsh habitat along the North American East and Gulf coasts. Because of their importance on Sabine NWR, they have been included among the marsh species. Seaside sparrows spend all of their lives in or near salt marsh habitats along the southeastern coasts of the United States, while Nelson's sparrow winters in salt marsh along the coast and breeds either inland in western Canada, along Hudson Bay, or along the St. Lawrence Seaway and east coast of Canada and the northeastern United States (Post et al. 2009, Shriver et al. 2011). Breeding habitat for seaside sparrows is emergent graminoid salt marsh. Nests are constructed above high tide in *Spartina patens*, *Distichlis spicata*, *Juncus* sp., or *Spartina alterniflora*. Preferred foraging habitat is open mud flats and creek banks. Wintering habitat for this species is typically in taller vegetation,

possibly including some woody component, where invertebrates and seeds are available and tidal flooding is infrequent (Post et al. 2009). Nelson's sparrows winter in salt marshes dominated by *Spartina* or occasionally in *Typha* spp. (Shriver et al. 2011).

B-3: FISHERIES

Because they are nutrient-rich, warm, and wet, Gulf coast marshes are some of the most diverse and productive systems in North America. Many commercial and forage fish and crustacean species breed in marsh habitats, and larval stages of these species find cover and food there. Important habitat components for these species include emergent vegetation, which provides cover and primary productivity, and deeper open water, which provides access to the marsh and refuge during dry, hot, and cold periods (Chabreck 1988). A natural salinity gradient, which fluctuates with season and freshwater flow rates, is necessary for maintenance of biological diversity in marsh ecosystems. Sediment deposition and erosion, tidal and freshwater flow, and fire are all critical ecosystem processes which must function to provide a healthy marsh environment for these species. Anthropogenic changes along the Gulf coast have interfered with all of these processes over large areas, and management of Sabine NWR must focus on restoring and maintaining them to provide usable habitat for aquatic species of concern. With the new water control structures, special efforts will have to continue to maintain connectivity between estuarine and marsh systems during critical migration periods for marine organisms while limiting saltwater intrusion into fresh and oligohaline environments.

C. REFUGE CONTRIBUTION TO HABITAT FOR RESOURCES OF CONCERN

Sabine NWR will continue to provide 92,061 acres of unimpounded, brackish, and intermediate marsh with approximately 60 to 65 percent open water and 35 to 40 percent emergent vegetation, 33,729 acres of impounded, fresh, and intermediate marsh with 40 to 60 percent cover of emergent vegetation and 40 to 60 percent open water. In addition, mud flats and tidal creek banks will continue to be provided as tides and weather permit. Future beneficial dredge spoil projects will provide short-term access to large areas (200-350 acres at a time, total of 1,865 acres) of shallow water/mud flat habitat as funding and opportunities are available. Most areas of upland habitat, both naturally occurring prairie islands and levees and spoil banks, will be managed to have <25 percent cover of woody vegetation, while rookery sites for colonial breeding waterbirds will be maintained on levees at current extent. Salinity levels will be managed through operation of the CS-23 water control structures to maintain current marsh vegetation across the eastern side of the refuge.

Table 6. Habitat requirements for 13 species of marsh birds found on Sabine NWR during the portion(s) of their life cycles when they are present on the refuge

SPECIES	HABITAT COMPONENT REQUIREMENTS ON SABINE NWR						
	Emergent graminoid marsh	Preferred or associated plant species	Open Water	Salinity	Water Depth	Other Requirements or Preferences	Large Scale Requirements
Pied-billed Grebe*	Marsh nest requires $\geq 10 \text{ cm}^2$ of stem basal area per m^2 of marsh		Breeds on ponds $>0.2 \text{ ha}$	Fresh to Brackish	$>0.25 \text{ m}$	Nest on floating platform among tall emergent vegetation in open water.	Area-dependent breeder (Naugle et al. 2001); Nests much more frequently in marsh habitat patches $\geq 5 \text{ ha}$ (Brown and Dinsmore 1986)
Yellow Rail	Yes	<i>Spartina spp.</i>				Drier portions of marsh	
Black Rail	Yes				Tolerates flooding in winter habitat		May tolerate more fragmentation in winter habitat
Clapper Rail*	Yes	<i>Spartina alterniflora</i> , <i>S. patens</i> , <i>Salicornia</i> spp., <i>Juncus roemerianus</i> , <i>Avicennia</i> spp.	Nests within 15m of open water	5.6-7.0 ppt	Shallow	Low marsh; scattered shrubs; 25% of marsh within 15m of a shoreline	

SPECIES	HABITAT COMPONENT REQUIREMENTS ON SABINE NWR						
	Emergent graminoid marsh	Preferred or associated plant species	Open Water	Salinity	Water Depth	Other Requirements or Preferences	Large Scale Requirements
King Rail	Yes	<i>Typha</i> spp., <i>Schoenoplectus</i> <i>olneyi</i> , <i>Spartina</i> <i>cynosuroides</i> , <i>Zizaniopsis miliacea</i> , <i>Panicum hemitomom</i> , <i>Cladium jamaicense</i> , <i>Echinochloa</i> spp., <i>Polygonum</i> spp.		Fresh to Brackish		High marsh with sparse woody vegetation	
Virginia Rail (Conway 1995)	Yes	<i>Typha</i> spp., <i>Schoenoplectus</i> spp.,	Uses open water as escape cover (swims underw ater)	Fresh to Salt Marsh	Mudflat to shallow water	Needs high invertebrate abundance in substrate	
Sora (Melvin and Gibbs 1996)	Yes			Fresh water, Brackish , Saline (Eddlem an et al. 1988)	May select areas of shallower water than Virginia Rails	Shallow water and emergent vegetation	

SPECIES	HABITAT COMPONENT REQUIREMENTS ON SABINE NWR						
	Emergent graminoid marsh	Preferred or associated plant species	Open Water	Salinity	Water Depth	Other Requirements or Preferences	Large Scale Requirements
Purple Gallinule*	Yes	<i>Brasenia schreberi</i> , <i>Nelumbo lutea</i> , <i>Nuphar lutea</i> , <i>Nymphaea odorata</i> , <i>Pontederia cordata</i> , <i>Sagittaria</i> spp., <i>Typha</i> spp., <i>Panicum</i> <i>hemitomon</i> , <i>Schoenoplectus</i> spp., <i>Zizaniopsis miliacea</i> , <i>Juncus</i> spp., <i>Lemna</i> spp., <i>Eichhornia</i> <i>crassipes</i> , <i>Potamogeton</i> spp., <i>Ceratophyllum</i> <i>demersum</i> , <i>Hydrilla</i> <i>verticillata</i> , <i>Cephalanthus</i> <i>occidentalis</i> .	Prefers <25% open water	0-5.0 ppt	deep: 0.25- 1.0m	Walks on floating or emergent vegetation to feed on invertebrates and flowers	

SPECIES	HABITAT COMPONENT REQUIREMENTS ON SABINE NWR						
	Emergent graminoid marsh	Preferred or associated plant species	Open Water	Salinity	Water Depth	Other Requirements or Preferences	Large Scale Requirements
Common Moorhen* (Bannor and Kiviat 2002)	Yes	<i>Panicum hemitomon</i> , <i>Juncus</i> spp., <i>Pontederia cordata</i> , <i>Peltandra virginica</i> , <i>Sagittaria lancifolia</i> , <i>Nuphar</i> spp., <i>Nymphaea</i> spp., <i>Nelumbo lutea</i> , <i>Ceratophyllum demersum</i> , <i>Potamogeton</i> spp., <i>Vallisneria americana</i> , <i>Hydrilla verticillata</i> ; <i>Spartina spartinae</i> in wintering habitat	yes, mixed with emerge nt marsh;	Fresh to slightly brackish		Robust graminoid vegetation, tidal marsh; floating and submerged aquatic vegetation is preferred; can use wide variety of habitats	
American Coot (Brisbin and Mowbray 2002)	Yes		Yes; uses bays and ponds, esp. in winter	Fresh to brackish	Deep water often used		

SPECIES	HABITAT COMPONENT REQUIREMENTS ON SABINE NWR						
	Emergent graminoid marsh	Preferred or associated plant species	Open Water	Salinity	Water Depth	Other Requirements or Preferences	Large Scale Requirements
Least Bittern*	Yes	<i>Typha</i> spp., <i>Carex</i> spp., <i>Schoenoplectus</i> spp., <i>Sagittaria</i> spp., <i>Myricus</i> spp.	yes, mixed with marsh and woody veg.	fresh to brackish	≤0.5m	clumps of woody vegetation	Nests much more frequently in marsh habitat patches ≥5ha (Brown and Dinsmore 1986)
Nelson's Sharp-tailed Sparrow	Yes			salt marsh			
Seaside Sparrow*	Yes						Area-dependent breeder; nests more frequently in marsh patches >100 ha in size (Benoit and Askins 2002)

*Species breeds on Sabine NWR (U.S. Fish and Wildlife Service 1992)

IV. Habitat Management Goals and Objectives

The overall habitat goal in the CCP (U.S. Fish and Wildlife Service 2007) for Sabine NWR is: “Maintain, restore, and enhance unique coastal wetland habitats on the refuge to provide favorable conditions to improve species diversity and richness of migratory birds and native terrestrial and aquatic species.” Goals and objectives in this HMP contribute to that overall goal.

A. COASTAL MARSH HABITAT GOAL

Maintain, restore, and enhance fresh, intermediate, and brackish coastal marsh habitats on Sabine NWR so that, as much as is possible, natural ecosystem processes operate to provide high quality habitat for waterfowl, waterbirds, and fisheries, in quantities which meet or exceed the refuge’s commitments under regional and national planning efforts and fulfill the purposes for which the refuge was created.

OBJECTIVE A-1: IMPOUNDED FRESHWATER MARSH HABITAT

Each year over the 15-year planning period covered by this HMP, actively manage impoundment units 1A (5,269 acres), 1B (2,058 acres), and 3 (26,402 acres) by manipulating the three CS-23 Water Control Structures (WCS), and by using control measures for exotic species to create the following conditions:

- 40 - 60 percent cover of emergent vegetation and 40 - 60 percent open water or cover by aquatic vegetation including water shield (*Brasenia schreberi*), white water lily (*Nymphaea odorata*), and American lotus (*Nelumbo lutea*).
- ≤25 percent cover of native woody vegetation on levees including waxmyrtle (*Morella cerifera*), hackberry (*Celtis laevigata*), willow (*Salix* spp.), and persimmon (*Diospyros virginiana*).
- Invasive exotic plant species, such as Chinese tallowtree (*Triadica sebifera*), chinaberry (*Melia azedarach*), and saltcedar (*Tamarix* spp.) on levees, and giant salvinia (*Salvinia molesta*), and water hyacinth (*Eichhornia crassipes*) in the water are kept below 10 percent cover.
- Invasive mammal nutria (*Myocastor coypus*) and feral hog (*Sus scrofa*) are controlled so that they do not have significant negative impacts on habitat (significant rooting, eatouts, or levee damage), or on resources of concern (predation of mottled duck nests).

CCP References: Objectives A2, A-7, B1-5, B7-9, B-11

Resources of Concern: waterfowl, marsh birds

Rationale: Freshwater and intermediate marsh provides foraging habitat, loafing habitat, escape cover, and sanctuary for waterfowl, marsh birds, and other resources of concern. Maintaining roughly 50 percent cover of open water is critical for providing habitat for waterfowl (Smith et al. 2004). Exotic invasive plants such as giant salvinia and water hyacinth provide very little benefit to waterfowl species and will quickly cover open water areas and out-compete native submerged and emergent vegetation if not controlled. Chinese tallowtree, chinaberry, and saltcedar will quickly dominate upland areas if not controlled, creating low-value woody overstory with little or

no herbaceous understory and rendering the areas unsuitable for mottled duck breeding. Controlling hogs and nutria maintains the integrity of the marsh habitat and reduces predation of nests by hogs. Providing a diverse mix of native forage species and tall emergent vegetation for escape cover increases the usefulness of impounded freshwater marsh habitat by increasing the number and kind of resources that it provides for marsh birds, waterfowl, and other resources of concern. Impounded marsh habitat is protected from hunting to provide sanctuary for waterfowl on Sabine NWR.

A hydrology feasibility study (CCP Objective A-2) conducted in 2009, which incorporated output from a hydrology model developed by Chevron Corporation, recommended that water management for the refuge be accomplished through the operation of these structures, and that the stoplog structures in Units 1A, 1B, and 3 be left open under normal circumstances. Chevron has made a map available, but has not released the report to the Service. Further, an engineering assessment of the South Levee of Unit 3 (Ellington 2005) reached the conclusion that the levee in question, which divides Unit 3 from Unit 4, was failing irreparably and should be breached. The cost of replacing this levee was estimated at over \$5 million in 2005. The engineer's recommendation was to breach the structure and restore Unit 3 to its natural, pre-1950s hydrology. As a consequence, these stoplog structures (Figure 2), which are currently functional, will not be replaced, although breaches in the levee left by Hurricane Rita were repaired. This decision reverses a strategy in the CCP (U.S. Fish and Wildlife Service 2007): Strategy (c) of Objective A-2 "Replace 5 water control structures at Units 1A, 1B, and 3" but is entirely consistent with the other strategies in Objective A-2, including (a) "Conduct a hydrology feasibility study to determine how best to manage Unit 3 post-Hurricane Rita. Use engineering studies and recommendations from experts to determine the best course of action for this unit." No changes to CCP goals or objectives result from changing this strategy. This change constitutes a Minor CCP Revision, (sensu U.S. Fish and Wildlife Service no date). See Appendix G for more information.

Adaptive Management Monitoring Elements: Impoundments	
Habitat Response Variables	Probable Methods
<ul style="list-style-type: none"> Emergent marsh/open water area ratio Plant diversity Cover of invasive exotic plants 	<ul style="list-style-type: none"> Vegetation transects
Wildlife Response Variables	Probable Methods
<ul style="list-style-type: none"> Breeding and wintering populations of waterfowl Marsh bird use 	<ul style="list-style-type: none"> aerial surveys ground surveys

OBJECTIVE A-2: *UNIMPOUNDED MARSH HABITAT*

Each year over the 15-year planning period covered by this HMP, manage by using water control structures, terraces, prescribed burning, shooting and trapping, 92,061 acres of fresh, intermediate, and brackish marsh in Units 1, 2, 4, 5, 6, 7, and West Cove to maintain the following conditions:

- A 35 - 45 percent emergent vegetation cover and 55 - 65 percent open water;
- Salinity levels to within limits for these habitat types (0.5 to 3.5 ppt for intermediate marsh, 3.5 to 10 ppt for brackish marsh);
- Invasive exotic species (Chinese tallowtree, chinaberry, and saltcedar on levees, giant salvinia and water hyacinth in the water are below 10 percent cover;
- Feral hogs and nutria are kept at levels below which resource damage (significant rooting, eatouts, levee weakening) occurs.

CCP References: Objectives A-3, A-7, B1-5, B7-11

Resources of Concern: waterfowl (wintering waterfowl, mottled ducks, northern pintails, geese), marsh birds, and fisheries.

Rationale: Unimpounded marsh habitat makes up the bulk of habitat on Sabine NWR. Loss of this habitat from saltwater intrusion, erosion, sea level rise, and subsidence threatens the ability of Sabine NWR to achieve its purpose and goals. Maintaining rough equality of open water (including submerged aquatic plants) and emergent vegetation cover optimizes waterfowl habitat while providing diverse habitats for marsh birds and estuarine fisheries. Rationale for exotic invasive control is the same as for Objective A-1.

An updated WCS operation plan (Louisiana Department of Natural Resources 2004) has been written which details water management for the new CS-23 WCS. Goals of the water management plan are to: (1) Increase water discharge capacity and reduce adverse impacts from excessive rainfall and storm surges which push excessive saline water into the area; (2) to curtail saltwater intrusion into interior low-salinity marshes; and (3) to provide greater cross-sectional area for improved estuarine-dependent fish and shellfish access.

Operation of the three structures will depend on salinity of incoming water, season, and the need to allow shrimp and fish ingress and egress. The goals of this water management plan are consistent with all relevant CCP objectives, including those for impounded and unimpounded marsh (Objectives A-2 and A-3) and those included under Goal B – Fish and Wildlife Management (U.S. Fish and Wildlife Service 2007).

Adaptive Management Monitoring Elements:	
Habitat Response Variables	Probable Methods
Emergent marsh/open water area ratio Plant diversity Cover of invasive exotic plants	Vegetation transects Aerial imagery
Wildlife Response Variables	Probable Methods
Breeding and wintering populations of waterfowl Marsh bird use	Aerial surveys, nest checks? Ground surveys

OBJECTIVE A-3: UNIMPOUNDED MARSH HABITAT RESTORATION

Over the 15-year planning period covered by this HMP, restore 1,865 acres of intermediate and/or brackish marsh in Unit 1 by use of beneficial dredge spoil application. If funding (CWPPRA) and partners (USACE) are available, one of these blocks will be restored every 2 - 3 years in conjunction with dredging of the Calcasieu Ship Channel.

CCP References: Objectives A-3, A-6, A-7, B1-5, B7-11.

Resources of Concern: waterfowl, marsh birds.

Rationale: Unimpounded marsh makes up the bulk of habitat on Sabine NWR. Loss of this habitat from saltwater intrusion, erosion, sea level rise, and subsidence threatens the ability of Sabine NWR to achieve its purpose and goals. Three blocks of formerly open water have been restored through this method in Unit 1 since 2002 (Figure 14). Two additional blocks, totaling 449 acres have been permitted. Five blocks of open water ranging in size from 250-350 acres have been proposed by the refuge for restoration (Figure 14).

Adaptive Management Monitoring Elements:	
Habitat Response Variables	Probable Methods
Emergent marsh/open water area ratio Plant diversity Cover of invasive exotic plants	Vegetation transects
Wildlife Response Variables	Probable Methods
Breeding and wintering populations of waterfowl Marsh bird use	Aerial surveys Ground surveys

B. NATIVE PRAIRIE HABITAT GOAL

On naturally occurring uplands in Sabine NWR, fire-sculpted native prairie and prairie-marsh ecotones will provide high-quality habitat for mottled ducks, prairie-dependent birds, and other native prairie species.

OBJECTIVE B-1: NATIVE PRAIRIE

Maintain native prairie habitat islands in Unit 5 by application of prescribed fire. Control woody plants and invasive exotics (particularly Chinese tallowtree) with fire or with mechanical or chemical treatments as necessary.

CCP References: Objectives A-5, A-7, B-2, B-6, B-11

Resources of Concern: Waterfowl (mottled ducks)

Rationale: Small inclusions of prairie habitat on higher ground provide important nesting habitat for mottled ducks. In addition, coastal prairie is a critically imperiled ecosystem. Maintaining examples of this vegetation type is important for reference sites and potentially as sources of seed for restoration projects in nearby areas.

Adaptive Management Monitoring Elements:	
Habitat Response Variables	Probable Methods
Plant species diversity and cover density and cover of exotic invasive plants	Vegetation transects
Wildlife Response Variables	Probable Methods
Breeding mottled ducks	Surveys

C. AQUATIC HABITAT GOAL

The Sabine NWR Comprehensive Conservation Plan (U.S. Fish and Wildlife Service 2007) lists a number of objectives under the goal “Maintain healthy and viable wildlife and fish populations on the refuge to contribute to the purpose for which it was established and to the mission of the National Wildlife Refuge System.” Healthy populations of fish and other aquatic organisms depend on maintaining seasonally appropriate salinities and good water quality year-round. The refuge has established the following step-down goal for aquatic habitats:

Contribute to the long-term protection and recovery of aquatic resources of concern on Sabine NWR and in the Gulf coast ecosystem by integrating, in a manner consistent with the purposes of the refuge, habitat management, monitoring, and adaptive management principles to maintain and enhance healthy aquatic habitats on Sabine NWR.

OBJECTIVE C-1: OLIGOHALINE AQUATIC HABITAT

Beginning in 2012, manage the fresh, intermediate, and brackish water habitats on Sabine NWR to maintain or enhance productivity and species diversity of native aquatic species by applying adaptive management principles to the operation of the CS-23 water control structures, within the guidelines set forth in the Operation, Maintenance, and Rehabilitation Plan for the structures (“WCS Operation Plan”) (Louisiana Department of Natural Resources 2004).

CCP References: Objectives A-2, A-3, A-4, A-7, B-8, B-11

Resources of Concern: Fisheries

Rationale: Protection and management of marshes from excessive saltwater intrusion will maintain the overall health of the ecosystem, including the aquatic resources which utilize the marsh either year-round, such as freshwater sport fish and the Mississippi diamondback terrapin, or as a nursery during the growing season, including many commercially and ecologically valuable marine fish and shrimp species. Maintaining diversity and primary productivity in the refuge will help achieve the

refuge purpose. The WCS Operation Plan provides for prevention of excessive saltwater intrusion and drainage of excessive water from the marsh, whether freshwater flow from the north or saltwater from storm surges which overtop the Gulf rim to the south of the refuge. In addition, habitat connectivity will be maintained during critical spring and fall migration periods for shrimp and fish by keeping minimum cross-sectional areas of the WCS open during these periods.

Existing canals provide access for oil and gas operations, refuge management operations, and the public, as well as facilitating drainage of upland areas upstream of the refuge. However, canals also represent entry-ways for saltwater intrusion, which causes conversion of marsh to open water and degrades both emergent marsh and aquatic habitats. A hydrology feasibility study conducted in 2003 revealed that saltwater was entering the refuge through canals including Central Canal, North Line Canal, and Black Bayou. After Hurricanes Rita and Ike plugged canals on the refuge with organic debris, the decision was made not to dredge and restore the canals, because they are no longer necessary for oil and gas or management access. This decision was made primarily to slow or reverse the conversion of marsh habitat to open water and fresh systems to saline. This decision partially reverses a strategy listed in the CCP (U.S. Fish and Wildlife Service 2007): Strategy (b) under Objective B-8 “Develop a project to dredge and maintain canals,” which the refuge managers now believe would be counterproductive to the overall goals of maintaining healthy habitat and fish and wildlife populations on the refuge. No changes to goals or objectives resulted from this strategy change. Deleting this strategy from the CCP constitutes a minor CCP revision (sensu U.S. Fish and Wildlife Service, no date). See Appendix G for more information.

Adaptive Management Monitoring Elements:	
Habitat Response Variables	Probable Methods
Salinity	Salinity monitoring stations as described in WCS Operation Plan
Wildlife Response Variables	Probable Methods
Productivity of shrimp and fish	Local catch data, creel surveys on the refuge

V. Habitat Management Strategies

The following management strategies will be employed to satisfy the habitat objectives stated in Chapter V: Habitat Management Goals and Objectives and the population objectives stated in the priority species accounts. Management strategies are described by habitat type.

A. IMPOUNDED MARSH HABITAT STRATEGIES

Maintaining a diverse, functioning freshwater marsh entails promoting all of the components of that system in the proper proportions. Emergent grasses and graminoid plants (e.g., cordgrass, sedges, rushes, and cattails) must be balanced with open water habitat and rooted, floating plants like white water lily, water shield, and American lotus. Also important are woody terrestrial plants on levees such as hackberry, waxmyrtle, willow, baccharis, and persimmon. All play a role in the life of waterfowl and other resources of concern, contributing to diversity of food, cover, nesting and brooding habitat. In freshwater impounded marsh habitat, four basic types of management strategies are available to managers at Sabine NWR: (1) Manipulation of water levels, (2) marsh restoration with beneficial use of dredge spoil, (3) prescribed fire, and (4) control of invasive species by mechanical or chemical means. Water manipulation and/or prescribed fire are vital in maintaining the desired vegetative species. Invasive aquatic, herbaceous, and woody plants would out-compete desirable species without water manipulation and/or prescribed fire, and in some cases without supplemental treatments such as herbicide application and mechanical removal, especially on levees and other upland areas.

A-1: POTENTIAL STRATEGIES

Hydrology is the most important tool in impoundment management. Draw-down and flood timing is crucial in producing diverse stands of desirable vegetation. The combination of water manipulation and fire will produce vegetation to sustain migrating waterfowl throughout the winter. Vegetation also serves as a nursery for invertebrates that are consumed by waterfowl preparing for the return migration north.

Water manipulation (retention of water and increase of water levels) in impounded units should take place from late August for early migrating waterfowl, and dewatering should be accomplished from early to late spring (Strader and Stinson 2005). Ideal depths in impoundment units are 8"-18." Marsh restoration with beneficial use of dredge spoil has been demonstrated on Sabine NWR. Dredging continues on Calcasieu Ship Channel, and dredge spoil will continue to be available.

Prescribed fire is used in impounded marsh habitat to control unwanted invasive plants, remove excess organic matter, and set back maidencane, cattails, and roseau cane to create space for more desirable emergent marsh plant species. Fires are usually applied during the fall of drought years, when the marsh can be dewatered. Return interval should average 3 years, but variation of interval length can be expected since droughts do not occur at precise intervals.

Dry periods allow organic matter which has accumulated in the sediment to oxidize, reversing the accumulation of muck and decreasing overall cover of emergent vegetation. Applying fire during the dry periods can accelerate this process by removing organic matter from sediment much more quickly (ground fire), and also by killing patches of vegetation which have established in organic soils. To avoid excessive open water, fire conditions should be selected that will produce patchy ground-fire

distribution. Drawdowns implemented for this purpose should coincide with drought conditions to be most effective and mimic natural processes.

The net effect of combining periodic draw-downs with fire is to increase or maintain open water as a component in the impoundment and to increase the diversity of the emergent and floating vegetation by increasing plant habitat diversity (i.e., depth, substrate). Diverse marsh vegetation coupled with adequate open water will produce high-quality habitat for wintering and year-round resident waterfowl and waterbirds, maintain quality fish habitat, and benefit many of the species with complementary habitat needs as listed in Table 5.

A-2: MANAGEMENT PRESCRIPTIONS

The following strategy prescriptions will provide the best mix of habitats for the resources of concern:

- Opportunistically utilize natural freshwater pulses to flood impounded units (1A, 1B, and 3) by manipulating the new CS-23 WCS in response to periods of high freshwater flow, while maintaining connectivity with the marine environment during crucial migration periods for larval shrimp and fish (details in water management plan).
- In conjunction with drought periods, but no more frequently than 3 years on any given site, draw down water levels allowing marsh to dry out, and apply prescribed fire as needed to reduce accumulation of organic matter, set back undesirable native and/or exotic plants, and increase areas of open water to maintain rough equality between emergent vegetation cover and open water. Fire should be applied during the fall and should be conducted under conditions which ensure that fuel (i.e., organic soil) consumption will be patchy.

Operation of the CS-23 water control structures will be regulated by the new Water Management Plan. Important elements of this plan include:

- WCS do not completely regulate flow; marsh is still open to unregulated flow at several locations.
- Normal operation of WCS will allow unimpeded flow of water.
- During periods of high saltwater intrusion potential, based on salinity monitoring data, flow can be restricted or halted through the three WCS.
- WCS will be opened during critical periods of ingress and egress for brown shrimp, white shrimp, and red drum.
- When a tropical storm surge is expected, the WCS will be closed to exclude the surge. (When predicted storm surge is greater than 3 feet, WCS will be left open to prevent damage to the structures and/or erosion of the levees surrounding the WCS. This procedure will be especially important in the event that a personnel evacuation is ordered in advance of the storm, leaving the WCS unstaffed.)

B. UNIMPOUNDED MARSH STRATEGIES

Units 1, 2, 4, 5, 6, 7, West Cove 1, 1A, 2, 3, 4 (92,061 acres)

Unimpounded marsh makes up the majority of habitat types on Sabine NWR. Emergent vegetation cover and species composition goals listed in Chapter IV can only be reached and maintained by a combination of restoration strategies including prescribed burning, beneficial use of dredge spoil material, construction of terraces in open-water areas, and control of saltwater intrusion with WCS.

B-1: POTENTIAL STRATEGIES

Prescribed burning in unimpounded marsh increases structural and species diversity by opening up spaces for establishment of new plants and by in some cases, removing organic soil layers and creating a dynamic matrix of emergent vegetation and open water. Burning is recommended from late summer to early fall to protect nesting birds in the spring and miss the late fall rains that would prevent a significant burn. Burning removes dense vegetation, reducing wildfire hazard while increasing habitat heterogeneity and plant diversity (Gordon et al. 1989).

Beneficial dredge material can be used to restore marsh which has been eroded away or has converted to open water because of saltwater intrusion, subsidence, or storm surge. Dredge material is available from the Calcasieu Ship Channel for application to Unit 1.

Terraces act to slow saltwater intrusion and reduce erosive wave action in open water areas. They have been shown to improve fish habitat and provide nesting habitat for shorebirds as well. Terrace construction is expensive, but if funding continues to be available from mitigation or other sources, this strategy can be pursued on portions of the refuge (mostly the western side) where dredge spoil is currently not available.

Finally, WCS can continue to be used to slow infiltration of saltwater during dry periods when the freshwater flow from the Sabine River and fresh marshes to the north of the refuge slows down and rainfall is inadequate. The refuge has three WCS, located at Hog Island Gully, West Cove, and Headquarters. Together, these structures will allow the management of water level and salinity on Units 1, 2, and 4.

B-2: MANAGEMENT PRESCRIPTIONS

The following prescriptions have been selected to provide the habitat conditions described above:

- Operate the WCS at Hog Island Gully, West Cove, and Headquarters in accordance with the Water Management Plan to control salinity in Units 1, 2, and 4, and to maintain elevated water levels in those units throughout the year, with an emphasis on moon cycles. WCSs will be opened at specified times, dimensions, and intervals between MAR 01-APR 15, MAY 15-JUN 14, JUN 15-JUL 31, opening date of white shrimp season-NOV 30 and later periods as dictated by weather, and SEP 01-SEP 30 to allow for ingress and egress of brown shrimp, white shrimp, and red drum.
- Terraces will continue to be constructed in open water areas in Units 5, 6, and 7 to prevent and reverse marsh loss through saltwater intrusion, wave action, and storm surge, as funding becomes available.

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- Prescribed fire will be applied to unimpounded marsh during dry periods on an average 3-year return interval as needed to maintain 35 - 45 percent emergent vegetation and 55 -65 percent open water. Fire will be applied under conditions which will result in patchy burns to avoid excessive removal of organic soils.
 - Continue to seek funding for, and carry out, marsh restoration projects through CWPPRA (or other sources which may become available). These projects will consist of beneficially depositing dredge spoil in Unit 1 as described and illustrated above.

C. UNDESIRABLE FLORA STRATEGIES

Invasive and exotic plant species can alter the functioning of native ecosystems and negatively affect wildlife. Effects can include decreased habitat suitability, loss of native species, reduction of native food sources, and increased soil erosion and alluviation. Therefore, a management strategy is required to control and attempt to eradicate exotic invasive species. Exotic and invasive plants which pose management challenges on Sabine NWR are listed in Table 2.

A number of strategies are available to managers at Sabine NWR to control exotic invasive and undesirable native plant species. Broadly, these can be divided into five categories: (1) Manipulation of hydrology (water levels and salinity), (2) biological control, (3) prescribed fire, (4) herbicides, and (5) mechanical treatments including manual removal.

C-1: POTENTIAL STRATEGIES

Hydrologic Manipulation

Adjusting water levels in impounded areas has long been used to affect vegetation composition on managed lands. Duration, season, and depth of flooding can be used to reduce or eliminate undesirable plants. On Sabine NWR, most of the plants which cause management problems are either found on levees where flooding is not possible, or are well adapted to flooded conditions. However, some of the most problematic exotic plants on the refuge, as well as the native maidencane, are intolerant of saline conditions. Raising salinity levels by opening water control structures during dry periods or high tides has the potential to control giant salvinia, which has been shown to be fairly intolerant of salinities above 100 mM (roughly 5.9 ppt) (Upadhyay and Panda 2005). Salinities in the brackish range also can be effective at reducing water hyacinth, which is intolerant of salinity above 2.4 ppt (Kikuchi et al. 1997). Maidencane is generally intolerant of salinities above 7-12 ppt. (Hester et al. 1998, Howard and Mendelssohn 1999) and could be controlled by increasing salinity in management units above these levels. Using saltwater to control exotic plants in fresh marsh can of course have negative effects on desirable freshwater vegetation, limiting the frequency with which this strategy can be used.

Biological Control

Biological control measures have been researched for many introduced pests in North America. For example, the weevil *Cyrtobagous salviniae* has been successfully used in tropical and temperate areas around the world to control giant salvinia (Julien et al. 2002, Tipping et al. 2008). This biological control agent has been recently released on Mandalay NWR in south-central Louisiana.

Prescribed Fire

Fire is a commonly used land management tool on Sabine NWR. Among its many uses are control of woody invasives in terrestrial environments such as levees and road banks. Here, growing-season fire cannot only top-kill tallowtree and saltcedar, but repeat treatments will reduce resprouting (i.e., kill root systems) as well (Grace et al. 2005). Fire also can be used to remove organic matter from marsh soils under dry conditions (ground fire), thus setting back succession, removing undesirable vegetation, and opening up more open-water areas. However, smoke management issues reduce the usefulness of this method near human habitation or transportation corridors.

Herbicides

Herbicide application can be used to control most undesirable plants, including all of the invasive exotics which pose management problems for Sabine NWR. However, consideration must be given to cost, potential damage to non-targeted plants, and other environmental consequences before the decision is made to apply herbicides on the refuge. All chemicals will be approved through the Pesticide Use Proposal process and will follow Integrated Pest Management Policy (569 FW 1).

Mechanical Treatments

Mechanical treatments, including mowing, disking, hand removal, and girdling (of woody stems), are all potentially useful for controlling the exotic invasive plant species which occur on Sabine NWR. However, because of cost and access considerations, extensive use of these methods, perhaps with the exception of mowing on levees and roadsides, will be limited.

C-2: MANAGEMENT PRESCRIPTIONS

Periodic drawdowns and application of herbicides and fire will be used as tools to control invasive plants including tallowtree, chinaberry, and saltcedar on levees and giant salvinia and water hyacinth in open-water areas. Exotic woody vegetation on levees will be treated with fire, approved herbicides, and/or mowing as needed to prevent them from exceeding 10 percent cover.

Prescribed fire will be applied to marsh and levees as needed on at least 20,000 acres per year to set back woody vegetation and unwanted herbaceous vegetation, including exotic and native species. Growing season burns will be utilized for controlling woody vegetation whenever feasible, because of their greater potential for causing root-kill of woody plants.

D. UNDESIRABLE FAUNA STRATEGIES

Feral swine are found on Sabine NWR. This animal poses a number of threats to wildlife and native systems on the refuge. Hogs damage natural vegetation through their feeding and rooting behavior, they negatively impact native wildlife populations through competition and direct predation, and they are reservoirs of diseases and parasites which can affect native animals, livestock, and even humans (Missouri Department of Conservation 2010, Miller and Synatzke 1993). By rooting and digging for food, feral hogs destroy fragile wetland plants and cause soil erosion and changes in successional patterns. They are omnivores, and will eat tubers, fruits, roots, and other plant material, decreasing the availability of these resources for native wildlife. They will also prey on eggs of ground-nesting birds and reptiles, and on the young of mammals such as rabbits and deer (Missouri Department of Conservation 2010). Diseases such as brucellosis and trichinosis are known to have been transmitted to humans and livestock by feral swine (Missouri Department of Conservation 2010).

Nutria are also found on Sabine NWR. Their populations fluctuate in response to storms, cold weather, predation, and other factors.

D-1: POTENTIAL STRATEGIES

Public hunting has been used on other refuges and managed lands, but has the disadvantage that it creates perverse incentives among the public to perpetuate the population of feral swine on the refuge, either by selectively taking boars, avoiding the take of sows with young, or even by actively (and illegally) releasing swine on the refuge.

Hogs may also be removed by qualified refuge personnel.

D-2: MANAGEMENT PRESCRIPTIONS

A Hog Management Plan for Sabine NWR was approved by the Service's Regional Office in October 2010. The refuge will conform to the strategies within that document. Feral swine will be managed by the following prescription:

- When resource damage caused by feral hogs becomes apparent, the Hog Management Plan will be in effect. Feral hogs are managed by the Southwest Louisiana National Wildlife Refuge Complex staff and Wildlife Services, which is contracted for hog eradication work.

Nutria will be managed by the following prescription:

- When populations reach levels of concern, nutria will be removed by refuge personnel or commercial trappers.

E. PRESCRIBED FIRE STRATEGIES

Fire management on Sabine NWR is focused on using prescribed fire to create or maintain desirable fire-maintained communities by approximating the prehistoric fire regime, taking into account the ecological changes that have taken place since settlement. Approaches identified in the CCP (U.S. Fish and Wildlife Service 2007) include the use of fire to remove accumulations of organic material (ground fires) during drought periods to set back succession and open up habitat, fuel- and hazard-reduction burns to reduce risk of uncontrollable wildfire, application of patchy or mosaic burns to avoid excess negative effects on secretive marsh birds, and the maintenance and restoration of coastal prairie remnants by application of fire on a 3-year return interval. In freshwater marsh, fires during dry periods will set back the natural accumulation of organic material in the soil and promote vegetation diversity and habitat structure (Chabreck 1988). Restoring fire as an ecosystem function in coastal prairie will retard the development of woody vegetation, including woody invasives like Chinese tallowtree, and promote grassland habitat preferred by grassland birds and other species (Grace et al. 2005). Diversity of fire by season, intensity, and areal extent is the key to mimicking prehistoric fire conditions and restoring the biological integrity, diversity, and ecosystem health of natural systems.

E-1: POTENTIAL STRATEGIES

Prescribed burns can be varied by season, intensity, and movement of the flame front with respect to wind direction (backing, flanking, or headfire). Depending on conditions selected, different amounts and types of fuels will be consumed (with different effects on vegetation and soil), and that

consumption can be over the entire burn unit or in patches. Constraints associated with prescribed fire include staff training, availability of qualified personnel, and equipment. Smoke may be a human safety/health hazard when burns occur close to highways and residences. The season of burn can affect the degree to which fire impacts vigor or mortality of bunch grasses and shrubs.

Prescribed fire may cause short-term negative effects by eliminating and/or reducing the quality of nesting cover for species such as least bittern (*Ixobrychus exilis*), king rail (*Rallus elegans*), purple gallinule (*Porphyrio martinica*), common moorhen (*Gallinula chloropus*), and black-necked stilt (*Himantopus mexicanus*).

Fire can be used effectively to remove accumulations of undesirable or dangerous levels of fuel, prevent succession to woody systems, promote seed production of herbaceous plants, and improve viability of seeds which are produced (Gordon et al. 1989). A mix of fire intensities, timing, and coverage will ensure the most diverse, resilient habitat.

Wildfires have similar effects to those of prescribed fires, and in many cases wildfire can be used to achieve management objectives. Service Policy 620 DM 1.14 (2) states: "Wildfires can be managed wholly or in part to benefit resource objectives if these strategies are addressed in the Fire Management Plan and associated land management plans." This is called "Appropriate Management Response." Integrating prescribed fire with wildfire management in this way can help achieve management objectives.

E-2: MANAGEMENT PRESCRIPTIONS

A Fire Management Plan has been written for Sabine NWR which details the use of prescribed fire on the refuge (U.S. Fish and Wildlife Service 2011). The following general prescriptions, consistent with that plan, will be followed for habitat management on the refuge:

- A total of at least 20,000 acres per year will be treated with prescribed fire or Appropriate Management Response to wildfires. Wildfires will be treated in accordance with the Fire Management Plan and may be used to achieve habitat management goals (wildland fire use) (U.S. Fish and Wildlife Service 2011).
- Fire will be used on levees and other lands to manage woody vegetation and reduce the cover of exotic woody plants such as tallowtree. Burns will be conducted during the growing season when feasible to increase root-kill on woody plants. Known or future designated rookery sites will not be burned.
- Prescribed fire (or wildfire under Appropriate Management Response) will be used during the dry season of dry years (late summer/early fall), no more frequently than every 3 years, to reduce peat accumulations in impounded units when emergent marsh vegetation becomes denser than target levels and open water falls below desired percentage (i.e., 40 percent). This treatment will also have the objectives of reducing accumulations of fuel and of opening up space for higher plant diversity in areas where roseau cane, maidencane, or cattails have established monocultures.

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- Prescribed fire will be used in unimpounded marsh units with an approximately 3-year fire return interval to remove excess fuel, increase vegetative diversity, maintain optimum mix of open water and emergent marsh vegetation, set back undesirable/exotic invasive plants, and maintain the health and diversity of coastal prairie patches.

Appendix A. Literature Cited

- Afton, A.D., and S.L. Paulus. 1992. Incubation and brood care. *in* Batt, B.D.J., A.D. Afton, M.G. Anderson, C.D. Ankney, D.H. Johnson, J.A. Kadlec, and G.L. Krapu, eds. Ecology and management of breeding waterfowl. University of Minnesota Press, Minneapolis, London, 645 pp.
- Allain, L., M. Vidrine, V. Grafe, C. Allen, and S. Johnson. 2000. Paradise Lost? the coastal prairie of Louisiana and Texas. US Fish and Wildlife Service/US Geological Survey, 39 pp.
- Aten, L.E., and C.N. Bollich. no date. The Mossy Grove tradition. Texasbeyondhistory.net website. Retrieved online 12SEP2011 at:
<http://www.texasbeyondhistory.net/coast/prehistory/images/mossy.html>.
- Bannor, B. K. and E. Kiviat. 2002. Common Moorhen (*Gallinula chloropus*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: <http://bna.birds.cornell.edu/bna/species/685>
- Barras, J.A., J.C. Bernier, and R.A. Morton. 2008. Land Area Change in Coastal Louisiana: A Multidecadal Perspective (from 1956 to 2006). U.S. Geological Survey Scientific Investigations Map 3019, scale 1:250,000, 14p. Pamphlet,
<http://pubs.usgs.gov/sim/3019/>
- Barras, J.A., S. Beville, D. Britsch, S. Hartley, S. Hawes, J. Johnston, P. Kemp, Q. Kinler, A. Martucci, J. Porthouse, D. Reed, K. Roy, S. Sapkota, and J. Suhayda. 2003. Historical and Projected Coastal Louisiana Land Changes: 1978-2050: USGS Open File Report 03-334.
- Batt, B.D.J., A.D. Afton, M.G. Anderson, C.D. Ankney, D.H. Johnson, J.A. Kadlec, and G.L. Krapu. 1992. Ecology and Management of Breeding Waterfowl. University of Minnesota Press, Minneapolis, MN 645 pp.
- Bedoya, M., Kates, J., and Van Metter, E. 2008. A primer on Climate Change and the National Wildlife Refuge System. A Report by the Graduate Program in Sustainable Development and Conservation Biology University of Maryland, College Park.
- Benfield, M., D. Baltz, G. Peterson, J. Fleeger, D. Lindstedt, and M. Bourgeois. no date. Biological Info: a shrimp's niche in its ecosystem. Louisiana State University Sea Grant web publication, viewed online at: <http://www.seagrantfish.lsu.edu/biological/shrimpniche.htm>.
- Benoit, L.K., and R.A. Askins. 2002. Relationship between habitat area and the distribution of tidal marsh birds. Wilson Bulletin 114:314-323.
- Brisbin, Jr., I. L. and T.B. Mowbray. 2002. American Coot (*Fulica americana*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: <http://bna.birds.cornell.edu/bna/species/697a>

-
- Brown, M., and J.J. Dinsmore. 1986. Implications of marsh size and isolation for marsh bird management. *Journal of Wildlife Management* 50:392-397.
- CDC. 2009. Climate Change and Public Health: Water- and Food-Borne Diseases. Centers for Disease Control and Prevention. Available: <http://www.cdc.gov/climatechange/effects/waterborne.htm>. Accessed January 21, 2010.
- Chabreck, R.H. 1988. Coastal marshes: ecology and wildlife management. University of Minnesota Press, Minneapolis, MN.
- Chabreck, R.H., and Linscombe, G., 1978, Vegetative type map of the Louisiana coastal marshes: Baton Rouge, Louisiana Department of Wildlife and Fisheries.
- Chabreck, R.H., and Linscombe, G., 1988, Vegetative type map of the Louisiana coastal marshes: Baton Rouge, Louisiana Department of Wildlife and Fisheries, set of 10 maps.
- Chabreck, R.H., and Linscombe, G., 1997, Vegetative type map of the Louisiana coastal marshes: Baton Rouge, Louisiana Department of Wildlife and Fisheries.
- Chabreck, R.H., Palmisano, A.W., Jr., and Joanen, T., 1968, Vegetative type map of the Louisiana coastal marshes: Baton Rouge, Louisiana Department of Wildlife and Fisheries.
- Connelly, W., L. Kerr, E. Martino, A. Peer, R. Woodland, and D. Secor. 2007. Climate and Saltwater Sport Fisheries: Prognosis for Change. Technical Report Series No. TS-537-07.
- Conway, C.J. 1995. Virginia Rail (*Rallus limicola*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: <http://bna.birds.cornell.edu/bna/species/173>
- Dahl, T.E. 1990. Wetland Losses in the United States 1780's to 1980's. U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC. Available: http://www.fws.gov/wetlands/_documents/gSandT/NationalReports/WetlandsLossesUS1780sto1980s.pdf. Accessed January 21, 2010.
- Eddleman, W. R., F. L. Knopf, B. Meanley, F. A. Reid, and R. Zembal. 1988. Conservation of North American rallids. *Wilson Bull.* 100:458-475.
- Ellington, B. 2005. Asset Condition Report, South Levee Unit 3, Sabine National Wildlife Refuge. US Fish and Wildlife Service, Atlanta, GA, 3 pp. Copy available in Refuge Headquarters.
- Emanuel, K. 2005. Increasing destructiveness of tropical cyclones over the past 30 years. *Nature* 436:686-688.
- Engeling, G.A. 1950. Nesting habits of the mottled duck in Colorado, Fort Bend and Brazoria Counties, Texas. M.S. Thesis. Texas A&M University, College Station. 137.
- Esslinger, C.G., and B.C. Wilson. 2001. North American waterfowl management plan, Gulf Coast Joint Venture: Chenier Plain Initiative. North American Waterfowl Management Plan, Albuquerque, NM. 28 pp. + appendix. (Revised 2003.)

-
- Fairbairn, S.E., and J.J. Dinsmore. 2001. Local and landscape-level influences on wetland bird communities of the prairie pothole region of Iowa, USA. *Wetlands* 21(1):41-47.
- Fassett, N.C. 1960. A manual of aquatic plants. University of Wisconsin Press, Madison, WI, 405 pp.
- Gordon, D.H., B.T. Gray, R.D. Perry, M.B. Prevost, T.H. Strange, and R.K. Williams. 1989. South Atlantic Coastal Wetlands. pp. 57-92 in Smith, L.M., R.L. Pederson, and R.M. Kaminski, eds., *Habitat Management for Migrating and Wintering Waterfowl in North America*, Lubbock, Texas Tech University Press, 574 pp.
- Grace, J.B., Allain, L.K., Baldwin, H.Q., Billock, A.G., Eddleman, W.R., Given, A.M., Jeske, C.W., and Moss, R. 2005. Effects of Prescribed Fire in the Coastal Prairies of Texas: USGS Open File Report 2005-1287.
- Haggard, J.V. no date. Neutral Ground. Handbook of Texas Online, Texas State Historical Association. Viewed online 12JAN2012 at: <http://www.tshaonline.org/handbook/online/articles/nbn02>.
- Haukos, D., S. Martinez, and J. Heltzel. 2010. Characteristics of ponds used by breeding mottled ducks on the Chenier Plain of the Texas Gulf Coast. *J. Fish and Wildl. Manage.* 1(2):93-101.
- Hebert, T. 2003. "The First Acadians in New Acadia, 1764-1784." *History of the Cajuns: Cajuns in the 18th Century*. Acadian-Cajun Genealogy and History. <http://www.acadian-cajun.com/hiscaj2b.htm>.
- Heitmeyer, M.E. 1988. Body composition of female mallards in winter in relation to annual cycle events. *Condor*, 90, 669-680.
- Heitmeyer, M.E. 2006. The importance of winter floods to mallards in the Mississippi Alluvial Valley. *Journal of Wildlife Management*, 70, 101-110.
- Heitmeyer, M. E. and Raveling, D.G. 1988. Winter resource use by three species of dabbling ducks in California. (Department of Wildlife and Fisheries Biology Final Report to Delta Waterfowl and Wetlands Research Center, Portage La Prairie, Manitoba, Canada,200). University of California, Davis.
- Henry, W.G. 1980. Populations and behavior of black brant at Humboldt Bay, California. M.S. Thesis, Humboldt State University, Arcata, 111.
- Hester, M.W., I.A. Mendelssohn, and K.L. McKee. 1998. Intraspecific variation in salt tolerance and morphology in *Panicum hemitomon* and *Spartina alterniflora* (Poaceae). *International Journal of Plant Sciences* 159(1):127-138.
- Hobaugh, W.C. 1984. Habitat use by snow geese wintering in southeast Texas. *J. Wildl. Manage.* 48(4):1085-1096. viewed online 03AUG2010 at: <http://www.jstor.org/stable/3801770>

-
- Howard, R.J. and I.A. Mendelssohn. 1999. Salinity as a constraint on growth of oligohaline marsh macrophytes. I. Species variation in stress tolerance. *Am. J. Bot.* 86(6):785-794.
- Hunter, W.C., W. Golder, S. Melvin, and J. Wheeler. 2006. Southeast United States regional waterbird conservation plan. Waterbird Conservation for the Americas. Viewed online 27APR2011 at: http://www.waterbirdconservation.org/southeast_us.html.
- Intergovernmental Panel on Climate Change 2007. Fourth Assessment Report: Climate Change 2007.
- International Workshop on Tropical Cyclones. 2006. Statement on tropical cyclones and climate change. Statement published November, 2006, by IWTC-6, San Jose, Costa Rica. Accessed online 07FEB2011 at: http://www.wmo.int/pages/prog/arep/tmrp/documents/iwtc_statement.pdf.
- Janetos, A.C., Hansen, L., Inouye, D., Kelly, B.P., Meyerson, L., Peterson, W., and Shaw, R. 2008. Biodiversity. In *The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity in the United States*, M. Walsh (managing ed.), P. Backlund, A. Janetos, and D. Schimel (convening lead authors). (A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change 151-181).
- Johnson, R.R., and J.J. Dinsmore. 1986. Habitat use by breeding Virginia Rails and Soras. *Journal of Wildlife Management* 50:387-392.
- Julien, M.H., T.D. Center, and P.W. Tipping. 2002. Floating fern (salvinia). in Driesche, F.V., Blossey, B., Hoodle, M., Lyon, S., and Reardon, R. *Biological Control of Invasive Plants in the Eastern United States*. USDA Forest Service Forest Health Technology Enterprise Team. Morgantown, WV. FHTET-2002-04. August 2002. 413 pp. Viewed online 04NOV2010 at: http://wiki.bugwood.org/Archive:BCIPEUS/Salvinia_molesta#History_of_Biological_Control_Efforts
- Kahl, R. 1991. Boating disturbance of canvasbacks during migration at Lake Poygan, Wisconsin. *Wildlife Society Bulletin*, 19,242-248.
- Kaminski, R.M. 1986. Habitat suitability index models: greater white-fronted goose (wintering). *Biological Report* 82(10.116), US Fish and Wildlife Service, 14 pp. Viewed online 03AUG2010 at: <http://www.nwrc.usgs.gov/wdb/pub/hsi/hsi-116.pdf>
- Kaminski, R.M., Davis, J.B., Essig, H.W., Gerard, P.D., and Reinecke, K.J. 2003. Waterfowl fall migration. *Journal of Wildlife Management*, 67, 542-550.
- Karl, T.R., G.A. Meehl, C.D. Miller, S.J. Hassol, A.M. Waple, and W.L. Murray (eds.). 2008. *Weather and Climate Extremes in a Changing Climate. Regions of Focus: North America, Hawaii, Caribbean, and U.S. Pacific Islands*. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. U.S. Department of Commerce, NOAA National Climatic Data Center, Washington, DC.

-
- Karl, T.R., Melillo, J.M., and Peterson, T.C. (eds.). 2009. Global Climate Change Impacts in the United States. Cambridge University Press, New York.
- Kikuchi, T., M. Takagi, E. Tokuhisa, T. Suzuki, W. Panjaitan, and M. Yasuno. 1997. Water hyacinth (*Eichhornia crassipes*) as an indicator to show the absence of *Anopheles suncaicus* larvae. Medical Entomology and Zoology 48(1): 11-18.
- Kniffen, F.B. 1968. Louisiana: it's land and people. Louisiana State University Press, Baton Rouge, 196 pp.
- Knutson, T.R. and Tuleya, R.E. 2004. Impact of CO₂-induced warming on simulated hurricane intensity and precipitation: sensitivity to the choice of climate model and convective parameterization. Journal of Climate, 17(18), 3477-3495.
- Kushlan, J.A., M.J. Steinkamp, K.C. Parsons, J. Capp, M.A. Cruz, M. Coulter, I. Davidson, L. Dickson, N. Edelson, R. Elliot, R.M. Erwin, S. Hatch, S. Kress, R. Milko, S. Miller, K. Mills, R. Paul, R. Phillips, J.E. Saliva, B. Sydeman, J. Trapp, J. Wheeler, and K. Wohl. 2002. Waterbird conservation for the Americas: The North American waterbird conservation plan, version 1. Waterbird Conservation for the Americas, Washington, DC, U.S.A., 78 pp.
- Laskowski, H. no date. Canada geese. Maryland Cooperative Extension Fact Sheet 612, 8 pp. viewed online 03AUG2010 at: <http://extension.umd.edu/publications/pdfs/fs612.pdf>
- Lazarine, P. no date. Common wetland plants of southeast Texas. US Army Corps of Engineers, Galveston District, 134 pp.
- Lester, G.D., S.G. Sorensen, P.L. Faulkner, C.S. Reid, and I.E. Maxit. 2005. Louisiana Comprehensive Wildlife Conservation Strategy. Louisiana Department of Wildlife and Fisheries. Baton Rouge. 455 pp.
- Linscombe, G., and R. Chabreck. no date. Task III.8—Coastwide aerial survey, brown marsh 2001 assessment: Salt marsh dieback in Louisiana—Brown marsh data information management system, accessed June 4, 2006, at http://brownmarsh.net/data/III_8.htm
- Lor, S., and R.A. Malecki. 2006. Breeding ecology and nesting habitat associations of five marsh bird species in western New York. Waterbirds 29:427-436.
- Louisiana Department of Natural Resources. 2004. Operation, maintenance, and rehabilitation plan for Sabine National Wildlife Refuge structure replacement project CS-23. LDNR Coastal Engineering Division, Lafayette, LA, 13 pp. + attachments.
- Louisiana Geological Survey Staff. 2008. Generalized Geology of Louisiana. Viewed online at: <http://www.lgs.lsu.edu/deploy/uploads/gengeotext.pdf>
- Louisiana Natural Heritage Program. 2009. The natural communities of Louisiana. Louisiana Department of Wildlife and Fisheries, Baton Rouge, 46 pp. Retrieved online: <http://www.wlf.louisiana.gov/wildlife/rare-natural-communities>.

-
- Lovich, J. 2006. Invasive plants of California's wildland: *Tamarix* spp. Viewed online at: <http://www.cal-ipc.org/ip/management/ipcw/pages/detailreport.cfm@usernumber=81&surveynumber=182.php>
- Melvin, S.M. and J.P. Gibbs. 1996. Sora (*Porzana carolina*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: <http://bna.birds.cornell.edu/bna/species/250>
- Merry, K., P. Bettinger, and J. Hepinstall. 2009. Physical and biological responses of forests to tropical cyclones affecting the United States Atlantic Ocean and Gulf of Mexico coasts. *Am. J. Env. Sci.* 5(1):784-800.
- Millennium Ecosystem Assessment. 2005. Ecosystems and Human Well-Being: Biodiversity Synthesis. World Resources Institute, Washington, DC.
- Miller, J.E., Synatzke, D.R. 1993. A National Prospective on Feral Swine in: Feral Swine: A Compendium for Resource Managers, March 24-25, 1993.
- Missouri Department of Conservation. 2010. Shoot 'em on sight. <http://mdc.mo.gov/landown/wild/nuisance/hogs/>
- Mitchell, R.J. and S.L. Duncan. 2009. Range of variability in southern coastal plain forests: its historical, contemporary, and future role in sustaining biodiversity. *Ecology and Society* 14(1):17.
- NASA. 2008. Glacial Sediments Add to Louisiana Coastal Subsidence: The Weight they Add to the Mississippi River Delta Contributes to the Sinking. Retrieved on October 29, 2009, from <http://geology.com/nasa/louisiana-coastal-subsidence.shtml>
- NAST. 2001. Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change. Report for the US Global Change Research Program. National Assessment Synthesis Team. Cambridge University Press, Cambridge, UK. Available:<http://www.usgcrp.gov/usgcrp/Library/nationalassessment/>. Accessed August 29, 2009.
- National Climatic Data Center. 2010. US Department of Commerce National Oceanic and Atmospheric Administration. Data retrieved online 13OCT2010 from: <http://www.ncdc.noaa.gov/oa/ncdc.html>.
- NatureServe. 2012. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available <http://www.natureserve.org/explorer>. (Accessed: May 21, 2012)
- Naugle, D.E., R.R. Johnson, M.E. Estey, and K.F. Higgins. 2001. A landscape approach to conserving wetland bird habitat in the prairie pothole region of eastern South Dakota. *Wetlands*: 21:1-17.

-
- Nicholls, R.J., P.P. Wong, V. Burkett, J. Codignotto, J. Hay, R. McLean, S. Ragoonaden, and C.D. Woodroffe. 2007. Coastal systems and low lying areas. In *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P.
- NOAA. 1975. The Coastline of the United States. Available:
http://shoreline.noaa.gov/_pdf/Coastline_of_the_US_1975.pdf. Accessed January 22, 2010.
- NOAA. 1990. *Estuaries of the United States: Vital Statistics of a National Resource Base*. Monograph. NOAA National Ocean Service, Strategic Assessment Branch, Rockville, MD.
- O'Neil, T., 1949, *The muskrat in Louisiana coastal marshes*: New Orleans, Louisiana Wildlife and Fisheries Commission, 28 p.
- Osnas, E.E. 2003. The role of competition and local habitat conditions for determining occupancy patterns in grebes. *Waterbirds* 26:209-216.
- Owens, M. 1997. Louisiana's traditional cultures: an overview. Viewed online at
http://www.louisianafolklife.org/LT/Maidas_Essay/main_introduction_onepage.html
- Paulus, S.L. 1984a. Behavioral ecology of mottled ducks in Louisiana. PhD Dissertation, Auburn University, Auburn, AL, 139 pp.
- Paulus, S.L. 1984b. Activity budgets of non-breeding gadwalls in Louisiana. *Journal of Wildlife Management*, 48, 371-380.
- Penland, S.S. and J.R. Suter. 1989. The Geomorphology of the Mississippi River chenier plain. *Marine Geology* , 90(4):231-240, 243-258.
- Post, W., W. Post and J. S. Greenlaw. 2009. Seaside Sparrow (*Ammodramus maritimus*), *The Birds of North America Online* (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: <http://bna.birds.cornell.edu/bna/species/127>
- Pyne, S.J. 1982. *Fire in America: a cultural history of wildland and rural fire*. University of Washington Press, Seattle, WA, 654 pp.
- Pyne, S.J. 1995. *World fire: the culture of fire on earth*. University of Washington Press, Seattle, WA, 384 pp.
- Reed, D.J., and L. Wilson. 2004. Coast 2050: a new approach to restoration of Louisiana coastal wetlands. *Physical Geography* 25(1):4-21.
- Region C Water Planning Group. 2010. 2011 Region C water plan. Freese and Nichols, Inc., Alan Plummer Associates, Inc., CP&Y, Inc., Cooksey Communications, Inc. Viewed online 17AUG2011 at:
http://www.regioncwater.org/Documents/index.cfm?PageNum_d=1&Category=2011+Region+C+Water+Plan.

-
- Reinecke, K.J., Kaminski, R.M., Moorhead D.J., Hodges, J.D., and Nassar, J.R. 1989. Mississippi Alluvial Valley habitat management for migrating and wintering waterfowl in North America. Lubbock, TX: Texas Tech University Press.
- Riffell, S.K., B.E. Keas, and T.M. Burton. 2003. Birds in North American great lakes coastal wet meadows: is landscape context important? *Landscape Ecology* 18:95- 111.
- Rorabaugh, J.C. and Zwank, P.J. 1983. Habitat suitability index models: mottled duck. U.S. Fish and Wildlife Service FWS/OBS-82/10.52.
- Roth, D.M. 1998. A historical study of tropical storms and hurricanes that have affected Southwest Louisiana and Southeast Texas. National Weather Service. Lake Charles, LA.
- Sasser, C.E., Visser, J.M., Mouton, Edmond, Linscombe, Jeb, and Hartley, S.B., 2008, Vegetation types in coastal Louisiana in 2007: U.S. Geological Survey Open-File Report 2008-1224, 1 sheet, scale 1:550,000.
- Shriver, W. G., T.P. Hodgman and A.R. Hanson. 2011. Nelson's Sparrow (*Ammodramus nelsoni*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: <http://bna.birds.cornell.edu/bna/species/719>
- Singleton, J.R. 1953. Mottled duck studies. in: Texas coast waterfowl survey. Texas Game and Fish Comm. Fed. Aid Rep. Serv., No.11.
- Smith, J.B. 2004. A Synthesis of the Potential Impacts of Climate Change on the United States. Pew Center on Global Climate Change, Arlington, VA.
- Smith, L.M., D.A. Haukos, and R.M. Prather. 2004. Avian response to vegetative pattern in playa wetlands during winter. *Wildlife Soc. Bull.* 32(2):474-480.
- Soil Conservation Service. 1995. Soil Survey of Cameron Parish, Louisiana. United States Department of Agriculture, 135 pp. Viewed online at soildatamart.nrcs.usda.gov/Manuscripts/LA023/0/Cameron.pdf
- Spearing, D. 1995. Roadside geology of Louisiana. Mountain Press Publ. Co., Missoula, MT, 225 pp.
- Strader, R. W. and Stinson, P.H. 2005. Moist-soil management guidelines for the U.S. Fish and Wildlife Service Southeast Region. Strickland, B. K., R.M. Kaminski, K. Nelms, and A. Tullos. 2009. Waterfowl Habitat Management Handbook for the Lower Mississippi Valley. Mississippi State University Extension Service Publication 1864, 31 pp.
- Strickland, B. K., R.M. Kaminski, K. Nelms, and A. Tullos. 2009. Waterfowl Habitat Management Handbook for the Lower Mississippi Valley. Mississippi State University Extension Service Publication 1864, 31 pp.
- Stutzenbaker, C.D. 1979. The mottled duck: its life history, ecology and management. Federal Aid Project W-96-R Austin, TX: Texas Parks and Wildlife Department.

-
- Swearingen, J. and K. Saltonstall. 2010. Phragmites field guide: distinguishing native and exotic forms of common reed (*Phragmites australis*) in the United States. Plant Conservation Alliance, Weeds Gone Wild. Viewed online 09MAR2011 at: <http://www.nps.gov/plants/alien/pubs/index.htm>.
- Swenson, E.M., and R.E. Turner. 1987. Spoil banks: effects on a coastal marsh water-level regime. *Estuarine, Coastal and Shelf Science* 24(5):599-609.
- Teague, J. 2003. CES203.550 Texas-Louisiana coastal prairie. pp. 51-52 in Appendix III: Wetland Ecological System Descriptions, NatureServe 2003. Viewed online at: http://www.natureserve.org/library/isolated_wetlands_05/Appendix_III_Ecological_Systems_Descriptions.pdf
- Terres, J. 1980. The Audubon Society encyclopedia of North American birds. New York: Alfred A. Knopf.
- Tesky, Julie L. 1993. *Anser albifrons*. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: <http://www.fs.fed.us/database/feis/>.
- Texas Invasives. 2010. Invasives database. Viewed online 04NOV2010 at: <http://www.texasinvasives.org/>
- Tipping, P.W., M.R. Martin, T.D. Center, and T.M. Davern. 2008. Suppression of *Salvinia molesta* Mitchell in Texas and Louisiana by *Cyrtobagous salviniae* Calder and Sands. *Aquatic Botany* 88:196-202. Viewed online 04JAN2012 at: <http://ddr.nal.usda.gov/dspace/bitstream/10113/32420/1/IND44244538.pdf>.
- Titus, J.G. Anderson, K.E. , Cahoon, D.R.,. Gesch, D.B., Gill, S.K., Gutierrez, B.T., Thieler, E.R., and Williams, S.J. 2009. Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region (A Report by the U.S. U.S. Environmental Protection Agency), Washington, D.C.: Climate Change Science Program and the Subcommittee on Global Change Research.
- Upadhyay, R.K., and S.K. Panda. 2005. Salt tolerance of two aquatic macrophytes, *Pistia stratiotes* and *Salvinia molesta*. *Biologia Plantarum* 49(1):157-159.
- U.S. Congressional Budget Office. 2009. Potential impacts of climate change in the United States. Retrieved April 2, 2010, from http://www.cbo.gov/ftpdocs/101xx/doc10107/05-04-ClimateChange_forWeb.pdf
- U.S. Department of Agriculture. 2008. Data Sets: Regional Agricultural Profile System. United States Department of Agriculture's Economic Research Service. Presentation tool for the 2002 Census of Agriculture. Available: <http://www.ers.usda.gov/data/RegionMapper/index.htm>. Accessed January 21, 2010.
- U.S. Environmental Protection Agency. 2009a. Climate Change Health and Environmental Effects: U.S. Regions. Available: <http://www.epa.gov/climatechange/effects/index.html>, Accessed August 29, 2009.

-
- U.S. Environmental Protection Agency. 2009b. Protocol for Developing Pathogen TMDLs. First Edition. 841-R-00-002. Available: http://www.epa.gov/owow/tmdl/pathogen_all.pdf. Accessed January 25, 2010.
- U.S. Fish and Wildlife Service. no date. Memorandum on conservation planning and policy guidance DCPD no. 2 – guidance for revising comprehensive conservation plans. Assistant Director, National Wildlife Refuge System, US Fish and Wildlife Service, Washington, DC, 5 pp.
- U.S. Fish and Wildlife Service. 1992. Birds of Sabine National Wildlife Refuge. U.S. Fish and Wildlife Service. Unpaginated. Jamestown, ND: Northern Prairie Wildlife Research Center Online. <http://www.npwrc.usgs.govsabine.htm>. Viewed online 01AUG2011 at: <http://www.npwrc.usgs.gov/resource/birds/chekbird/r4/sabine.htm>.
- U.S. Fish and Wildlife Service. 1998. Expanding the Vision, 1998 Update, North American Waterfowl Management Plan.
- U.S. Fish and Wildlife Service. 2002. Southwest Louisiana Refuges Complex, Visitor Services Review, June 17-20, 2002.
- U.S. Fish and Wildlife Service 2006. Cameron Prairie National Wildlife Refuge comprehensive conservation plan. United States Fish and Wildlife Service Region 4, Atlanta, GA, 217 pp.
- U.S. Fish and Wildlife Service 2007. Sabine National Wildlife Refuge comprehensive conservation plan. United States Fish and Wildlife Service Region 4, Atlanta, GA, 235 pp.
- U.S. Fish and Wildlife Service 2008. Threatened and Endangered Species of Louisiana. Atlanta: USFWS.
- U.S. Fish and Wildlife Service 2010a. Rising to the Urgent Challenge. Strategic Plan for Responding to Accelerating Climate Change. U.S. Fish and Wildlife Service, 32 pp.
- U.S. Fish and Wildlife Service 2010b. Sabine-Neches Waterway channel improvements project, Jefferson and Orange Counties, Texas, and Cameron Parish, Louisiana Fish and Wildlife Coordination Act report. U.S. Fish and Wildlife Service, Clear Lake, TX and Lafayette, LA, 53 pp.
- U.S. Fish and Wildlife Service. 2011. Fire management plan Sabine National Wildlife Refuge Louisiana. US Fish and Wildlife Service, Region 4, Atlanta, GA, 46 pp.
- U.S. Forest Service. 2010. Forest Inventory Data Online (FIDO). U.S. Forest Service. 2004 and 2005 Estimates. Available <http://fiatools.fs.fed.us/fido/>. Accessed January 21, 2010.
- U.S. Global Change Research Program. 2009. Southeast Climate Change. Retrieved on April 14, 2010 from <http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts/regional-climate-change-impacts/southeast>.

-
- Van Fleet, T. and F. Juanes. 2009. *Phragmites australis* – cryptic invasion of the common reed in North America. Encyclopedia of Earth. viewed online 04NOV2010 at: http://www.eoearth.org/article/Phragmites_australis_-_cryptic_invasion_of_the_Common_Reed_in_North_America
- Walsh, R.A. 1994. *Panicum hemitomon*. In: Fire Effects Information System, available online at: <http://www.fs.fed.us/database/feis/>.
- Walters, N.F. 2000. Nesting activities of mottled ducks in the Mississippi River delta. M.S. Thesis, School of Forestry, Wildlife, and Fisheries, Louisiana State University, Baton Rouge, 63 pp.
- Webster, P.J., G.J. Holland, J.A. Curry, and H.R. Chang. 2005. Changes in tropical cyclone number, duration, and intensity in a warming environment. Science 309:1844-1846.
- Wang, J.D. 1987. Hurricane effects on surface Gulf Stream currents. Ocean Engineering 14(3): 165-180.
- White, D. H. and James, D. 1978. Differential use of freshwater environments by wintering waterfowl of coastal Texas. Wilson Bulletin, 90(1), 99-111.
- White, P.S., Wilds, S.P. and Thunhorst, G.A. 1998. Regional trends of biological resources-southeast. In: Mac, M.J., Opler, P.A., Puckett Haeker, C.E. and Doran, P.D., Editors, 1998. Status and Trends of the Nation's Biological Resources, Vol. 1, US Geological Survey, Reston, VA, pp. 255–314.. Viewed 02AUG2010 at: <http://www.nwrc.usgs.gov/sandt/Sotheast.pdf> [sic]
- Willis, C.G., B.R. Ruhfel, R.B. Primack, A.J. Miller-Rushing, J.B. Losos, C.C. Davis. 2010. Favorable Climate Change Response Explains Non-Native Species' Success in Thoreau's Woods. PLoS ONE 5(1): e8878. doi:10.1371/journal.pone.0008878.
- Wilson, B.C. 2007. North American Waterfowl Management Plan, Gulf Coast Joint Venture: Mottled Duck Conservation plan. North American Waterfowl Management Plan, Albuquerque New Mexico.

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Appendix C. Refuge Biota

PLANTS

Common Name	Scientific Name
Salt (Saline) Marsh 10.0 ppt and above	
Annual Glasswort	<i>Salicornia bigelovii</i>
Black Needlerush	<i>Juncus roemerianus</i>
Marsh Elder	<i>Iva frutescens</i>
Smooth Cordgrass	<i>Spartina alterniflora</i>
Brackish Marsh 3.5 to 10.0 ppt	
Baccharis	<i>Baccharis halimifolia</i>
Black Needlerush	<i>Juncus roemerianus</i>
Cattail	<i>Typha spp.</i>
Coastal Water-Hyssop	<i>Bacopa monnieri</i>
Coffeeweed	<i>Sesbania macrocarpa</i>
Dog Fennel	<i>Eupatorium capillifolium</i>
Dwarf Spikerush	<i>Eleocharis parvula</i>
Eurasian Watermilfoil	<i>Myriophyllum spicatum</i>
Flatsedges	<i>Cyperus spp.</i>
Hogcane	<i>Spartina cynosuroides</i>
Marsh Elder	<i>Iva frutescens</i>
Marshhay Cordgrass	<i>Spartina patens</i>
Narrow-leaf Groundsel Bush	<i>Baccharis angustifolia</i>
Olney's Three-Square	<i>Scirpus americanus</i>
Pennywort	<i>Hydrocotyle spp.</i>
Roseau Cane	<i>Phragmites australis</i>

Common Name	Scientific Name
Salt Grass	<i>Distichlis spicata</i>
Saltmarsh Bulrush	<i>Scirpus robustus</i>
Saltmarsh Mallow	<i>Kosteletzkya virginica</i>
Saltmarsh Morning Glory	<i>Ipomoea sagittata</i>
Seashore Paspalum	<i>Paspalum vaginatum</i>
Smooth Cordgrass	<i>Spartina alterniflora</i>
Three-cornered Grass	<i>Scirpus olneyi</i>
Sprangletop	<i>Leptochloa fascicularis</i>
Wigeongrass	<i>Ruppia maritima</i>
Intermediate Marsh 0.5 to 3.5 ppt	
Alligator Weed	<i>Alternanthera philoxeroides</i>
Baccharis	<i>Baccharis halimifolia</i>
Banana Water Lily	<i>Nymphaea mexicana</i>
Barnyard Grass	<i>Echinochloa crusgalli</i>
Black Needlerush	<i>Juncus roemerianus</i>
Bulltongue	<i>Sagittaria lancifolia</i>
Bullwhip	<i>Schoenoplectus californicus</i>
Cattail	<i>Typha spp.</i>
Coastal Water-Hyssop	<i>Bacopa monnieri</i>
Coffeeweed	<i>Sesbania macrocarpa</i>
Coontail	<i>Ceratophyllum demersum</i>
Dog Fennel	<i>Eupatorium capillifolium</i>
Dwarf Spikerush	<i>Eleocharis parvula</i>
Eurasian Watermilfoil	<i>Myriophyllum spicatum</i>
Fall Panicum	<i>Panicum dichotomiflorum</i>

Common Name	Scientific Name
Flatsedges	<i>Carex spp.</i>
Frogbit	<i>Limnobium spongia</i>
Frogfruit	<i>Phyla nodiflora</i>
Hogcane	<i>Spartina cynosuroides</i>
Marshhay Cordgrass	<i>Spartina patens</i>
Pennywort	<i>Hydrocotyle spp.</i>
Pigweed	<i>Chenopodium album</i>
Roseau Cane	<i>Phragmites australis</i>
Sago Pondweed	<i>Potamogeton pectinatus</i>
Saltmarsh Bulrush	<i>Schoenoplectus robustus</i>
Saltmarsh Mallow	<i>Kosteletzkya virginica</i>
Saltmarsh Morning Glory	<i>Ipomoea sagittata</i>
Sawgrass	<i>Cladium jamaicense</i>
Seashore Paspalum	<i>Paspalum vaginatum</i>
Softstem Bullrush	<i>Schoenoplectus tabernaemontani</i>
Southern Naiad	<i>Najas guadalupensis</i>
Sprangletop	<i>Leptochloa fascicularis</i>
Spikerushes	<i>Eleocharis spp.</i>
Thin-leaf Pondweed	<i>Potamogeton pusillus</i>
Three-cornered Grass	<i>Scirpus olneyi</i>
Walter's Millet	<i>Echinochloa walteri</i>
Wax-Myrtle	<i>Morella cerifera</i>
Widgeon Grass	<i>Ruppia maritima</i>
Freshwater Marsh 0.0 to 0.5 ppt	
Alligator Weed	<i>Alternanthera philoxeroides</i>

Common Name	Scientific Name
American Lotus	<i>Nelumbo lutea</i>
Baccharis	<i>Baccharis halimifolia</i>
Baldcypress	<i>Taxodium distichum</i>
Banana Water Lily	<i>Nymphaea mexicana</i>
Barnyard Grass	<i>Echinochloa crusgalli</i>
Black Needlerush	<i>Juncus roemerianus</i>
Black Willow	<i>Salix nigra</i>
Beggar's Tick	<i>Bidens laevis</i>
Blue Water Lily	<i>Nymphaea elegans</i>
Brazilian Verbena	<i>Verbena brasiliensis</i>
Brownseed Paspalum	<i>Paspalum plicatulum</i>
Bulltongue	<i>Sagittaria lancifolia</i>
Bullwhip	<i>Schoenoplectus californicus</i>
Bushy Bluestem	<i>Andropogon glomeratus</i>
Buttonbush	<i>Cephalanthus occidentalis</i>
Cattail	<i>Typha spp.</i>
Chinese Tallow	<i>Triadica sebifera</i>
Coastal Water-Hyssop	<i>Bacopa monnieri</i>
Coffeeweed	<i>Sesbania macrocarpa</i>
Common Bladderwort	<i>Utricularia vulgaris</i>
Coontail	<i>Ceratophyllum demersum</i>
Curly-leaf Dock	<i>Rumex crispus</i>
Duckweed	<i>Lemna minor</i>
Dog Fennel	<i>Eupatorium capillifolium</i>
Dwarf Spikerush	<i>Eleocharis parvula</i>

Common Name	Scientific Name
Eurasian Watermilfoil	<i>Myriophyllum spicatum</i>
Fall Panicum	<i>Panicum dichotomiflorum</i>
False Garlic	<i>Nothoscordum bivalve</i>
Fanwort	<i>Cabomba caroliniana</i>
Flatsedges	<i>Cyperus spp.</i>
Floating Water Primrose	<i>Ludwigia peploides</i>
Frogbit	<i>Limnobium spongia</i>
Frogfruit	<i>Phyla nodiflora</i>
Giant Cutgrass	<i>Zizaniopsis miliacea</i>
Giant Ragweed	<i>Ambrosia trifida</i>
Horned Beakrush	<i>Rhynchospora corniculata</i>
Hydrilla	<i>Hydrilla verticillata</i>
Iris	<i>Iris virginica</i>
Jungle Rice	<i>Echinochloa colonum</i>
Maidencane	<i>Panicum hemitomon</i>
Marshhay Cordgrass	<i>Spartina patens</i>
Mosquito-Fern	<i>Azolla caroliniana</i>
Muskgrass	<i>Chara spp.</i>
Parrot Feather	<i>Myriophyllum aquaticum</i>
Pennywort	<i>Hydrocotyle spp.</i>
Pickernelweed	<i>Pontederia cordata</i>
Rattlebox	<i>Sesbania drummondii</i>
Roseau cane	<i>Phragmites australis</i>
Sago Pondweed	<i>Potamogeton pectinatus</i>
Saltmarsh Mallow	<i>Kosteletzkya virginica</i>

Common Name	Scientific Name
Saltmarsh Morning Glory	<i>Ipomoea sagittata</i>
Sawgrass	<i>Cladium jamaicense</i>
Seashore Paspalum	<i>Paspalum vaginatum</i>
Smartweed	<i>Polygonum spp.</i>
Softstem Bullrush	<i>Schoenoplectus tabernaemontani</i>
Southern Naiad	<i>Najas guadalupensis</i>
Southern Swamp Lily	<i>Crinum americanum</i>
Spadderdock	<i>Nuphar lutea</i>
Spikerushes	<i>Eleocharis spp.</i>
Sprangletop	<i>Leptochloa fascicularis</i>
Squarestem Spikerush	<i>Eleocharis quadrangulata</i>
Sumpweed	<i>Iva annua</i>
Thalia	<i>Thalia dealbata</i>
Thin-leaf Pondweed	<i>Potamogeton pusillus</i>
Three-cornered Grass	<i>Scirpus olneyi</i>
Toothache Tree	<i>Zanthoxylum clava-herculis</i>
Vasey Grass	<i>Paspalum urvillei</i>
Walter's Millet	<i>Echinochloa walteri</i>
Water Hyacinth	<i>Eichhornia crassipes</i>
Water Lettuce	<i>Pistia stratiotes</i>
Water Pepper	<i>Polygonum hydropiperoides</i>
Water Shield	<i>Brasenia schreberi</i>
Waxmyrtle	<i>Morella cerifera</i>
White-topped Sedge	<i>Rhynchospora colorata</i>
White Water Lily	<i>Nymphaea odorata</i>

Common Name	Scientific Name
Wigeongrass	<i>Ruppia maritima</i>
Bird's Eye Bush	<i>Ochna serrulata</i>
Chocolate Weed	<i>Melochia corchorifolia</i>
Grasslike Fimbry	<i>Fimbristylis miliacea</i>
Red Rice	<i>Oryza punctata</i>

Family	Scientific Name
Coastal Prairie Marceaux Island	
10-May-05	
Chris Reid and Patti Faulkner, LA Nat. Heritage, Larry Allain, USGS	
Apiaceae	<i>Limnoscium pinnatum</i>
Aclepiadaceae	<i>Asclepias viridis</i>
Asteraceae	<i>Acmella oppositifolia</i> var. <i>repens</i>
Asteraceae	<i>Ambrosia psilostachya</i>
Asteraceae	<i>Boltonia (asteroides)</i>
Asteraceae	<i>Euthamia</i> sp.
Asteraceae	<i>Iva annua</i>
Asteraceae	<i>Iva frutescens</i>
Asteraceae	<i>Solidago canadensis</i>
Asteraceae	<i>Solidago sempervirens</i>
Asteraceae	<i>Symphyotrichum</i> sp.
Boraginaceae	<i>Heliotropium curassavicum</i>
Campanulaceae	<i>Triodanis perfoliata</i> var. <i>biflora</i>
Caryophyllaceae	<i>Spergularia salina</i>
Chenopodiaceae	<i>Chenopodium album</i>

Family	Scientific Name
Chenopodiaceae	<i>Sueda linearis</i>
Convolvulaceae	<i>Dichondra caroliniensis</i>
Cyperaceae	<i>Carex annectens</i> Bicknell (possibly)
Cyperaceae	<i>Carex festucacea</i> Willd.
Cyperaceae	<i>Carex longii</i> Mackensie
Cyperaceae	<i>Cyperus retroflexus</i> Vahl. var. <i>fraternus</i> (Kunth) Kuntze
Cyperaceae	<i>Cyperus virens</i>
Cyperaceae	<i>Eleocharis montevidensis</i> Kunth
Cyperaceae	<i>Rhynchospora recognita</i> (Gale) Kral
Ebenaceae	<i>Diospyros virginiana</i>
Euphorbiaceae	<i>Triadica sebifera</i>
Fabaceae	<i>Chamaecrista fasciculata</i>
Fabaceae	<i>Galactia volubilis</i>
Fabaceae	<i>Lathyrus pusillus</i> Ell.
Fabaceae	<i>Mimosa nuttallii</i>
Fabaceae	<i>Neptunia pubescens</i>
Fabaceae	<i>Vicia villosa</i> Roth
Gentianaceae	<i>Sabatia (campestris)</i>
Gentianaceae	<i>Sabatia angularis</i> (L.) Pursh
Iridaceae	<i>Sisyrinchium</i> spp.
Juncaceae	<i>Juncus brachycarpus</i> Engelm.
Juncaceae	<i>Juncus elliotii</i> Chapman
Juncaceae	<i>Juncus marginatus</i> Rostk.
Liliaceae	<i>Nothoscordum bivalve</i>
Malvaceae	<i>Modiola caroliniana</i>

Family	Scientific Name
Onagraceae	<i>Ludwigia palustris</i>
Onagraceae	<i>Ludwigia uruguayensis</i>
Orchidaceae	<i>Spiranthes vernalis</i> Engelm. & Gray
Oxalidaceae	<i>Oxalis dillenii</i>
Passifloraceae	<i>Passiflora incarnata</i>
Poaceae	<i>Agrostis hyemalis</i> (Walt.) B.S.P.
Poaceae	<i>Andropogon glomeratus</i>
Poaceae	<i>Briza minor</i>
Poaceae	<i>Cynodon dactylon</i>
Poaceae	<i>Dichanthelium dichotomum</i> (L.) Gould ssp. <i>roanokense</i> (Ashe) Lelong
Poaceae	<i>Dichanthelium oligosanthos</i> (Schultes) Gould ssp. <i>scriberianum</i> (Nash.) Freckmann & Lelong
Poaceae	<i>Dichanthelium</i> spp.
Poaceae	<i>Dichanthelium strigosum</i> (Muhl. ex Ell.) Freckmann var. <i>leucoblepharis</i> (Trin.) Freckmann
Poaceae	<i>Dichanthelium dichotomum</i> (L.) Gould ssp. <i>yadkinense</i> (Ashe) Freckmann & Lelong
Poaceae	<i>Panicum hians</i>
Poaceae	<i>Panicum</i> sp. (Possibly <i>P. hallii</i>)
Poaceae	<i>Paspalum plicatulum</i>
Poaceae	<i>Paspalum urvillei</i>
Poaceae	<i>Phalaris angusta</i> Nees. ex Trin.
Poaceae	<i>Spartina spartinae</i>
Poaceae	<i>Steinchisma hians</i> (Ell.) Nash
Polygonaceae	<i>Rumex crispus</i> L.
Rosaceae	<i>Rosa bracteata</i>

Family	<i>Scientific Name</i>
Rosaceae	<i>Rubus sp.</i>
Rubiaceae	<i>Diodia virginiana</i>
Rubiaceae	<i>Galium tinctorium L.</i>
Scrophulariaceae	<i>Agalinis fasciculata</i>
Scrophulariaceae	<i>Agalinis heterophylla (Nutt.) Small</i>
Solanaceae	<i>Lycium carolinianum</i>
Ulmaceae	<i>Celtis laevigata</i>
Verbenaceae	<i>Verbena bonariensis</i>

ANIMALS

Common Name	Scientific Name
BIRDS	
Loons	
Common Loon	<i>Gavia immer</i>
Grebes	
Pied-billed Grebe	<i>Podilymbus podiceps</i>
Horned Grebe	<i>Podiceps auritus</i>
Eared Grebe	<i>Podiceps nigricollis</i>
Pelicans and their Allies	
American White Pelican	<i>Pelecanus erythrorhynchos</i>
Double-crested Cormorant	<i>Phalacrocorax auritus</i>
Neotropic Cormorant	<i>Phalacrocorax brasilianus</i>
Anhinga	<i>Anhinga anhinga</i>
Magnificent Frigatebird	<i>Fregata magnificens</i>
Herons, Egrets, and Allies	
American Bittern	<i>Botaurus lentiginosus</i>
Least Bittern	<i>Ixobrychus exilis</i>
Great Blue Heron	<i>Ardea herodias</i>
Great Egret	<i>Ardea alba</i>
Snowy Egret	<i>Egretta thula</i>
Little Blue Heron	<i>Egretta caerulea</i>

Common Name	Scientific Name
Tricolored Heron	<i>Egretta tricolor</i>
Reddish Egret	<i>Egretta rufescens</i>
Cattle Egret	<i>Bubulcus ibis</i>
Green Heron	<i>Butorides virescens</i>
Black-crowned Night-Heron	<i>Nycticorax nycticorax</i>
Yellow-crowned Night-Heron	<i>Nycticorax violacea</i>
Ibis, Spoonbill, and Stork	
Glossy Ibis	<i>Plegadis falcinellus</i>
White Ibis	<i>Eudocimus albus</i>
White-faced Ibis	<i>Plegadis chihi</i>
Roseate Spoonbill	<i>Platalea ajaja</i>
Wood Stork	<i>Mycteria americana</i>
Sandhill Crane	<i>Grus canadensis</i>
Waterfowl	
Fulvous Whistling-Duck	<i>Dendrocygna bicolor</i>
Black-bellied Whistling Duck	<i>Dendrocygna autumnalis</i>
Greater White-fronted Goose	<i>Anser albifrons</i>
Snow Goose	<i>Chen caerulescens</i>
Ross's Goose	<i>Chen rossii</i>
Canada Goose	<i>Branta canadensis</i>
Wood Duck	<i>Aix sponsa</i>

Common Name	Scientific Name
Green-winged Teal	<i>Anas crecca</i>
American Black Duck	<i>Anas rubripes</i>
Mottled Duck	<i>Anas fulvigula</i>
Mallard	<i>Anas platyrhynchos</i>
Northern Pintail	<i>Anas acuta</i>
Blue-winged Teal	<i>Anas discors</i>
Cinnamon Teal	<i>Anas cyanoptera</i>
Northern Shoveler	<i>Anas clypeata</i>
Gadwall	<i>Anas strepera</i>
American Wigeon	<i>Anas americana</i>
Canvasback	<i>Aythya valisineria</i>
Redhead	<i>Aythya americana</i>
Ring-necked Duck	<i>Aythya collaris</i>
Lesser Scaup	<i>Aythya affinis</i>
Common Goldeneye	<i>Bucephala clangula</i>
Bufflehead	<i>Bucephala albeola</i>
Hooded Merganser	<i>Lophodytes cucullatus</i>
Common Merganser	<i>Mergus merganser</i>
Red-breasted Merganser	<i>Mergus serrator</i>
Ruddy Duck	<i>Oxyura jamaicensis</i>
Vultures, Hawks, and Allies	

Common Name	Scientific Name
Black Vulture	<i>Coragyps atratus</i>
Turkey Vulture	<i>Cathartes aura</i>
Osprey	<i>Pandion haliaetus</i>
Bald Eagle	<i>Haliaeetus leucocephalus</i>
Northern Harrier	<i>Circus cyaneus</i>
Sharp-shinned Hawk	<i>Accipiter striatus</i>
Cooper's Hawk	<i>Accipiter cooperii</i>
Red-shouldered Hawk	<i>Buteo lineatus</i>
Broad-winged Hawk	<i>Buteo platypterus</i>
Red-tailed Hawk	<i>Buteo jamaicensis</i>
American Kestrel	<i>Falco sparverius</i>
Merlin	<i>Falco columbarius</i>
Peregrine Falcon	<i>Falco peregrinus</i>
Northern Caracara	<i>Caracara cheriway</i>
Gallinaceous Birds (Quail, Turkey, and Allies)	
Northern Bobwhite Quail	<i>Colinus virginianus</i>
Rails, Gallinules, Coots, and Cranes	
Yellow Rail	<i>Coturnicops noveboracensis</i>
Black Rail	<i>Laterallus jamaicensis</i>
Clapper Rail	<i>Rallus longirostris</i>
King Rail	<i>Rallus elegans</i>

Common Name	Scientific Name
Virginia Rail	<i>Rallus limicola</i>
Sora	<i>Porzana carolina</i>
Purple Gallinule	<i>Porphyrio martinica</i>
Common Moorhen	<i>Gallinula chloropus</i>
American Coot	<i>Fulica americana</i>
Shorebirds	
Black-bellied Plover	<i>Pluvialis squatarola</i>
American Golden-Plover	<i>Pluvialis dominica</i>
Wilson's Plover	<i>Charadrius wilsonia</i>
Semipalmated Plover	<i>Charadrius semipalmatus</i>
Killdeer	<i>Charadrius vociferus</i>
Black-necked Stilt	<i>Himantopus mexicanus</i>
American Avocet	<i>Recurvirostra americana</i>
Greater Yellowlegs	<i>Tringa melanoleuca</i>
Lesser Yellowlegs	<i>Tringa flavipes</i>
Solitary Sandpiper	<i>Tringa solitaria</i>
Willet	<i>Catoptrophorus semipalmatus</i>
Spotted Sandpiper	<i>Actitis macularia</i>
Upland Sandpiper	<i>Bartramia longicauda</i>
Whimbrel	<i>Numenius phaeopus</i>
Long-billed Curlew	<i>Numenius americanus</i>

Common Name	Scientific Name
Marbled Godwit	<i>Limosa fedoa</i>
Ruddy Turnstone	<i>Arenaria interpres</i>
Red Knot	<i>Calidris canutus</i>
Sanderling	<i>Calidris alba</i>
Semipalmated Sandpiper	<i>Calidris pusilla</i>
Western Sandpiper	<i>Calidris mauri</i>
Least Sandpiper	<i>Calidris minutilla</i>
White-rumped Sandpiper	<i>Calidris fuscicollis</i>
Pectoral Sandpiper	<i>Calidris melanotos</i>
Dunlin	<i>Calidris alpina</i>
Stilt Sandpiper	<i>Calidris himantopus</i>
Short-billed Dowitcher	<i>Limnodromus griseus</i>
Long-billed Dowitcher	<i>Limnodromus scolopaceus</i>
Buff-breasted Sandpiper	<i>Tryngites subruficollis</i>
Common Snipe	<i>Gallinago gallinago</i>
American Woodcock	<i>Scolopax minor</i>
Laughing Gull	<i>Larus atricilla</i>
Franklin's Gull	<i>Larus pipixcan</i>
Bonaparte's Gull	<i>Larus philadelphia</i>
Ring-billed Gull	<i>Larus delawarensis</i>
Herring Gull	<i>Larus argentatus</i>

Common Name	Scientific Name
Gull-billed Tern	<i>Sterna nilotica</i>
Caspian Tern	<i>Sterna caspia</i>
Royal Tern	<i>Sterna maxima</i>
Common Tern	<i>Sterna hirundo</i>
Forster's Tern	<i>Sterna forsteri</i>
Least Tern	<i>Sterna antillarum</i>
Black Tern	<i>Childonias niger</i>
Black Skimmer	<i>Rynchops niger</i>
Pigeons and Doves	
Mourning Dove	<i>Zenaida macroura</i>
Cuckoos	
Black-billed Cuckoo	<i>Coccyzus erythrophthalmus</i>
Yellow-billed Cuckoo	<i>Coccyzus americanus</i>
Owls	
Barn Owl	<i>Tyto alba</i>
Eastern Screech Owl	<i>Megascops asio</i>
Great Horned Owl	<i>Bubo virginianus</i>
Burrowing Owl	<i>Athene cunicularia</i>
Short-eared Owl	<i>Asio flammeus</i>
Nightjars	
Common Nighthawk	<i>Chordeiles minor</i>

Common Name	Scientific Name
Chuck-will's widow	<i>Caprimulgus carolinensis</i>
Swifts and Hummingbirds	
Chimney Swift	<i>Chaetura pelagica</i>
Ruby-throated Hummingbird	<i>Archilochus colubris</i>
Kingfishers	
Belted Kingfisher	<i>Megaceryle alcyon</i>
Woodpeckers	
Red-headed Woodpecker	<i>Melanerpes erythrocephalus</i>
Yellow-bellied Sapsucker	<i>Sphyrapicus varius</i>
Downy Woodpecker	<i>Picoides pubescens</i>
Northern Flicker	<i>Colaptes auratus</i>
Flycatchers	
Olive-sided Flycatcher	<i>Contopus cooperi</i>
Eastern Wood-pewee	<i>Contopus virens</i>
Yellow-bellied Flycatcher	<i>Empidonax flaviventris</i>
Acadian Flycatcher	<i>Empidonax virescens</i>
Eastern Phoebe	<i>Sayornis phoebe</i>
Vermilion Flycatcher	<i>Pyrocephalus rubinus</i>
Great Crested Flycatcher	<i>Myiarchus crinitus</i>
Western Kingbird	<i>Tyrannus verticalis</i>
Eastern Kingbird	<i>Tyrannus tyrannus</i>

Common Name	Scientific Name
Scissor-tailed Flycatcher	<i>Tyrannus forficatus</i>
Martins and Swallows	
Purple Martin	<i>Progne subis</i>
Tree Swallow	<i>Iridoprocne bicolor</i>
Northern Rough-winged Swallow	<i>Stelgidopteryx serripennis</i>
Cliff Swallow	<i>Petrochelidon pyrrhonota</i>
Barn Swallow	<i>Hirundo rustica</i>
Jays and Crows	
Blue Jay	<i>Cyanocitta cristata</i>
Fish Crow	<i>Corvus ossifragus</i>
Nuthatches	
Red-breasted Nuthatch	<i>Sitta canadensis</i>
Creepers	
Brown Creeper	<i>Certhia americana</i>
Wrens	
Carolina Wren	<i>Thryothorus ludovicianus</i>
Winter Wren	<i>Troglodytes troglodytes</i>
Sedge Wren	<i>Cistothorus platensis</i>
Marsh Wren	<i>Cistothorus palustris</i>
Kinglets and Gnatcatchers	
Golden-crowned Kinglet	<i>Regulus satrapa</i>

Common Name	Scientific Name
Ruby-crowned Kinglet	<i>Regulus calendula</i>
Blue-gray Gnatcatcher	<i>Polioptila caerulea</i>
Bluebirds, Thrushes and Robins	
Eastern Bluebird	<i>Sialia sialis</i>
Veery	<i>Catharus fuscescens</i>
Gray-cheeked Thrush	<i>Catharus minimus</i>
Swainson's Thrush	<i>Catharus ustulatus</i>
Hermit Thrush	<i>Catharus guttatus</i>
Wood Thrush	<i>Hylocichla mustelina</i>
American Robin	<i>Turdus migratorius</i>
Thrashers	
Gray Catbird	<i>Dumetella carolinensis</i>
Brown Thrasher	<i>Toxostoma rufum</i>
Pipits	
American Pipit	<i>Anthus rubescens</i>
Waxwings	
Cedar Waxwing	<i>Bombycilla cedrorum</i>
Starling	
European Starling	<i>Sturnus vulgaris</i>
Shrike	
Loggerhead Shrike	<i>Lanius ludovicianus</i>

Common Name	Scientific Name
Vireos	
White-eyed Vireo	<i>Vireo griseus</i>
Blue-headed Vireo	<i>Vireo solitarius</i>
Yellow-throated Vireo	<i>Vireo flavifrons</i>
Warbling Vireo	<i>Vireo gilvus</i>
Red-eyed Vireo	<i>Vireo olivaceus</i>
Warblers	
Blue-winged Warbler	<i>Vermivora pinus</i>
Golden-winged Warbler	<i>Vermivora chrysoptera</i>
Tennessee Warbler	<i>Vermivora peregrina</i>
Orange-crowned Warbler	<i>Vermivora celata</i>
Nashville Warbler	<i>Vermivora ruficapilla</i>
Yellow Warbler	<i>Dendroica petechia</i>
Chestnut-sided Warbler	<i>Dendroica pensylvanica</i>
Magnolia Warbler	<i>Dendroica magnolia</i>
Cape May Warbler	<i>Dendroica tigrina</i>
Black-throated Blue Warbler	<i>Dendroica caerulescens</i>
Yellow-rumped Warbler	<i>Dendroica coronata</i>
Black-throated Green Warbler	<i>Dendroica virens</i>
Blackburnian Warbler	<i>Dendroica fusca</i>
Yellow-throated Warbler	<i>Dendroica dominica</i>

Common Name	Scientific Name
Prairie Warbler	<i>Dendroica discolor</i>
Palm Warbler	<i>Dendroica palmarum</i>
Bay-breasted Warbler	<i>Dendroica castanea</i>
Blackpoll Warbler	<i>Dendroica striata</i>
Cerulean Warbler	<i>Dendroica cerulea</i>
Black-and-white Warbler	<i>Mniotilta varia</i>
American Redstart	<i>Setophaga ruticilla</i>
Prothonotary Warbler	<i>Protonotaria citrea</i>
Worm-eating Warbler	<i>Helmitheros vermivorus</i>
Ovenbird	<i>Seiurus aurocapilla</i>
Northern Waterthrush	<i>Seiurus noveboracensis</i>
Louisiana Waterthrush	<i>Seiurus motacilla</i>
Kentucky Warbler	<i>Oporornis formosus</i>
Mourning Warbler	<i>Oporornis philadelphia</i>
Hooded Warbler	<i>Wilsonia citrina</i>
Canada Warbler	<i>Wilsonia canadensis</i>
Yellow-breasted Chat	<i>Icteria virens</i>
Tanagers	
Summer Tanager	<i>Piranga rubra</i>
Scarlet Tanager	<i>Piranga olivacea</i>
Western Tanager	<i>Piranga ludoviciana</i>

Common Name	Scientific Name
New World Finches	
Northern Cardinal	<i>Cardinalis cardinalis</i>
Rose-breasted Grosbeak	<i>Pheucticus ludovicianus</i>
Blue Grosbeak	<i>Passerina caerulea</i>
Indigo Bunting	<i>Passerina cyanea</i>
Painted Bunting	<i>Passerina ciris</i>
Dickcissel	<i>Spiza americana</i>
Sparrows	
Eastern Towhee	<i>Pipilo erythrophthalmus</i>
Field Sparrow	<i>Spizella pusilla</i>
Vesper Sparrow	<i>Pooecetes gramineus</i>
Lark Sparrow	<i>Chondestes grammacus</i>
Savannah Sparrow	<i>Passerculus sandwichensis</i>
LeConte's Sparrow	<i>Ammodramus leconteii</i>
Nelson's Sharp-tailed Sparrow	<i>Ammodramus nelsoni</i>
Seaside Sparrow	<i>Ammodramus maritimus</i>
Fox Sparrow	<i>Passerella iliaca</i>
Song Sparrow	<i>Melospiza melodia</i>
Lincoln's Sparrow	<i>Melospiza lincolnii</i>
Swamp Sparrow	<i>Melospiza georgiana</i>
White-throated Sparrow	<i>Zonotrichia albicollis</i>

Common Name	Scientific Name
White-crowned Sparrow	<i>Zonotrichia leucophrys</i>
Dark-eyed Junco	<i>Junco hyemalis</i>
Blackbirds, Grackles, Cowbirds and Orioles	
Red-winged Blackbird	<i>Agelaius phoeniceus</i>
Eastern Meadowlark	<i>Sturnella magna</i>
Western Meadowlark	<i>Sturnella neglecta</i>
Yellow-headed Blackbird	<i>Xanthocephalus xanthocephalus</i>
Rusty Blackbird	<i>Euphagus carolinus</i>
Boat-tailed Grackle	<i>Quiscalus major</i>
Common Grackle	<i>Quiscalus quiscula</i>
Brown-headed Cowbird	<i>Molothrus ater</i>
Orchard Oriole	<i>Icterus spurius</i>
Baltimore Oriole	<i>Icterus galbula</i>
Old World Finches	
Purple Finch	<i>Carpodacus purpureus</i>
American Goldfinch	<i>Carduelis tristis</i>
Weaver Finches	
House Sparrow	<i>Passer domesticus</i>
MAMMALS	
Marsupials	
Virginia Opossum	<i>Didelphis marsupialis</i>

Common Name	Scientific Name
Edentates	
Nine-banded armadillo	<i>Dasypus novemcinctus</i>
Insectivores	
Least Shrew	<i>Cryptotis parva</i>
Bats	
Red Bat	<i>Lasiurus borealis</i>
Seminole Bat	<i>Lasiurus seminolus</i>
Yellow Bat	<i>Lasiurus ega</i>
Eastern Pipistrelle	<i>Pipistrellus subflavus</i>
Evening Bat	<i>Nycticeius humeralis</i>
Brazilian (Mexican) Free-tailed Bat	<i>Tadarida brasiliensis</i>
Carnivores	
Coyote	<i>Canis latrans</i>
Gray Fox	<i>Urocyon cinereoargenteus</i>
Red Fox	<i>Vulpes vulpes</i>
Raccoon	<i>Procyon lotor</i>
Mink	<i>Mustela vison</i>
Striped Skunk	<i>Mephitis mephitis</i>
Spotted Skunk	<i>Spilogale putorius</i>
River Otter	<i>Lutra canadensis</i>
Bobcat	<i>Lynx rufus</i>

Common Name	Scientific Name
Ungulates	
White-tailed Deer	<i>Odocoileus virginianus</i>
Feral swine	<i>Sus scrofa</i>
Rodents	
Marsh Rice Rat	<i>Oryzomys palustris</i>
Fulvous Harvest Mouse	<i>Reithrodontomys fulvescens</i>
Hispid Cotton Rat	<i>Sigmodon hispidus</i>
Muskrat	<i>Ondatra zibethicus</i>
House Mouse	<i>Mus musculus</i>
Black Rat	<i>Rattus rattus</i>
Norway Rat	<i>Rattus norvegicus</i>
Nutria	<i>Myocastor coypus</i>
Fox Squirrel	<i>Sciurus niger</i>
Lagomorphs	
Swamp Rabbit	<i>Sylvilagus aquaticus</i>
Eastern Cottontail	<i>Sylvilagus floridanus</i>
REPTILES AND AMPHIBIANS	
Alligator	
American Alligator	<i>Alligator mississippiensis</i>
Lizards	
Green Anole	<i>Anolis carolinensis</i>

Common Name	Scientific Name
Broadhead Skink	<i>Eumeces laticeps</i>
Ground Skink	<i>Scinella lateralis</i>
Five-lined Skink	<i>Eumeces fasciatus</i>
Slender Glass Lizard	<i>Ophisaurus attenuatus</i>
Turtles	
Snapping Turtle	<i>Chelydra serpentina</i>
Alligator Snapping Turtle	<i>Macrochelys temminckii</i>
Mississippi Mud Turtle	<i>Kinosternon subrubrum hippocrepis</i>
Common Slider	<i>Trachemys scripta</i>
Spiny Softshell Turtle	<i>Apalone spinifera</i>
Chicken Turtle	<i>Deirochelys reticularia</i>
Eastern Box Turtle	<i>Terrapene carolina carolina</i>
Stinkpot Turtle	<i>Sternotherus odoratus</i>
Mississippi Diamondback Terrapin	<i>Malaclemys terrapin pileata</i>
Gulf Coast Box Turtle	<i>Terrapene carolina major</i>
Kemp's Ridley Sea Turtle	<i>Lepidochelys kempii</i>
Snakes	
Southern Water Snake	<i>Nerodia fasciata</i>
Mississippi Green Water Snake	<i>Nerodia cyclopion</i>
Diamondback Water Snake	<i>Nerodia rhombifer</i>
Brown Snake	<i>Storeria dekayi</i>

Common Name	Scientific Name
Western Ribbon Snake	<i>Thamnophis proximus proximus</i>
Rainbow Snake	<i>Farancia erytrogramma</i>
Glossy Crayfish Snake	<i>Regina rigida</i>
Eastern Hognose Snake	<i>Heterodon platirhinos</i>
Mud Snake	<i>Farancia abacura</i>
Racer	<i>Coluber constrictor</i>
Rat Snake	<i>Drymobius elaphe</i>
Common Kingsnake	<i>Lampropeltis getulus</i>
Southern Copperhead	<i>Agkistrodon contortrix contortrix</i>
Cottonmouth	<i>Agkistrodon piscivorus</i>
Pigmy Rattlesnake	<i>Sistrurus miliarius</i>
Yellow-bellied Water Snake	<i>Nerodia erythrogaster flavigaster</i>
Rough Green Snake	<i>Opheodrys aestivus</i>
Graham's Crayfish Snake	<i>Regina grahamii</i>
Salamanders	
Three-toed Amphiuma	<i>Amphiuma tridactylum</i>
Frogs and Toads	
Gulf Coast Toad	<i>Bufo valliceps valliceps</i>
Northern Cricket Frog	<i>Acris crepitans crepitans</i>
Green Tree Frog	<i>Hyla cinerea</i>
Eastern Narrow-mouthed Toad	<i>Gastrophryne carolinensis</i>

Common Name	Scientific Name
Bullfrog	<i>Rana catesbeiana</i>
Pig Frog	<i>Rana grylio</i>
Green Frog	<i>Rana clamitans melanota</i>
Southern Leopard Frog	<i>Rana utricularia</i>
Squirrel Tree Frog	<i>Hyla squirella</i>
Woodhouse Toad	<i>Bufo woodhousii woodhousii</i>
MARINE INVERTEBRATES	
Jellyfish	
Portuguese Man-of-War	<i>Physalia physalis</i>
Sea Nettle	<i>Chrysaora quinquecirrha</i>
Cabbagehead Jellyfish	<i>Stomolophus meleagris</i>
Phosphorus Jellyfish	<i>Mnemiopsis mccradyi</i>
Marine Round Worms	
Blood Worm	<i>Glycera americana</i>
Periscope Tube Worm	<i>Oiopatra cuprea</i>
Oyster Blister Worm	<i>Polydora websteri</i>
Snails	
Marsh Periwinkle	<i>Littoraria irrorata</i>
Common Mud Snail	<i>Nassarius vibex</i>
White Slipper Shell	
Atlantic Slipper Shell	

Common Name	Scientific Name
Common Marsh Snail	
Southern Oyster Drill	<i>Thais haemostoma</i>
Clams and Oysters	
Ribbed Mussel	<i>Geukensea demissa</i>
Hooked Mussel	<i>Ishadium recurvum</i>
Eastern Oyster	<i>Crassostrea virginica</i>
Road Shell Clam	<i>Rangia cuneata</i>
Small Macoma	<i>Macoma mitchelli</i>
Constricted Macoma	<i>Macoma constricta</i>
Southern Quahog	<i>Mercenaria campechiensis</i>
Squids	
Squids	<i>Loligo pealei</i>
Barnacles	
Acorn Barnacle	<i>Balanus sp.</i>
Crabs and Shrimp	
Speckled Crab	<i>Arenaeus cribrarius</i>
Blue Crab	<i>Callinectes sapidus</i>
Flat Mud Crab	<i>Eurypanaoplus depressus</i>
Stone Crab	<i>Menippe mercenaria</i>
Common Mud Crab	<i>Panopeus harrisi</i>
Harris Mud Crab	<i>Rithropanopeus harrisi</i>

Common Name	Scientific Name
Red-jointed Fiddler Crab	<i>Uca minax</i>
Sand Fiddler	<i>Uca pugillator</i>
Mud Fiddler	<i>Uca pugnax</i>
Fiddler Crab	<i>Uca rapax</i>
Spined Fiddler Crab	<i>Uca spinicarpa</i>
Wharf Crab	<i>Sesarma cinereum</i>
Purple Marsh Crab	<i>Sesarma reticulatum</i>
Dark Shore Crab	<i>Pachygrapsus gracilis</i>
Mottled Shore Crab	<i>Pachygrapsus transversus</i>
Green Porcelain Crab	<i>Petrolisthes armatus</i>
Striped Porcelain Crab	<i>Porcellana sigsbeiana</i>
Mussel Crab	<i>Pinnotheres maculatus</i>
Oyster Crab	<i>Pinnotheres ostreum</i>
Spider Crab	<i>Libinia dubia</i>
Striped Hermit Crab	<i>Clibanarius vittatus</i>
Surf Hermit	<i>Isocheles wurdemanni</i>
Long-armed Hermit Crab	<i>Pagurus longicarpus</i>
White River Crayfish	<i>Procambarus acutus</i>
Red Swamp Crayfish	<i>Procambarus clarkii</i>
Flat-browed Mud Shrimp	<i>Upogebia affinis</i>
Brown Shrimp	<i>Farfantepenaeus aztecus</i>

Common Name	Scientific Name
White Shrimp	<i>Litopenaeus setiferus</i>
Pink Shrimp	<i>Farfantepenaeus duorarum</i>
Seabob Shrimp	<i>Xiphopenaeus kroyeri</i>
Freshwater Shrimp	<i>Macrobrachium spp.</i>
Aviu Shrimp	<i>Acetes americanus</i>
Grass Shrimp	<i>Palaemonetes spp.</i>
Big-clawed Snapping Shrimp	<i>Alpheus heterochaelis</i>
Mantis Shrimp	<i>Squilla empusa</i>
Isopods and Amphipods	
Wood-boring Isopod	<i>Limnoria tripunctata</i>
Rock Louse	<i>Ligia exotica</i>
Bopyrissa wolffi (no common name)	<i>Bopyrissa wolffi</i>
Smooth-backed sphaeroma	<i>Sphaeroma quadridentatus</i>
Fish Louse	<i>Cymothoa spp.</i>
Wharf Roach	<i>Ligia spp.</i>
Beach Flea	<i>Orchestia grillus</i>
Scud	<i>Gammarus mucronatus</i>
Marsh Hopper	<i>Talorchestia spp.</i>
FISH	
Stingrays	
Atlantic Stingray	<i>Dasyatis sabina</i>

Common Name	Scientific Name
Gars	
Spotted Gar	<i>Lepisosteus oculatus</i>
Longnose Gar	<i>Lepisosteus osseus</i>
Alligator Gar	<i>Lepisosteus spatula</i>
Bowfins	
Bowfin	<i>Amia calva</i>
Tarpons	
Ladyfish	<i>Elops saurus</i>
Freshwater Eels	
American Eel	<i>Anguilla rostrata</i>
Snake Eels	
Speckled Worm Eel	<i>Myrophis punctatus</i>
Shrimp Eel	<i>Ophichthus gomesii</i>
Herrings	
Skipjack Herring	<i>Alosa chrysochloris</i>
Gulf Menhaden	<i>Brevoortia patronus</i>
Gizzard Shad	<i>Dorosoma cepedianum</i>
Threadfin Shad	<i>Dorosoma petenense</i>
Scaled Sardine	<i>Harengula pensacolae</i>
Atlantic Thread Herring	<i>Opisthonema oglinum</i>
Anchovies	

Common Name	Scientific Name
Striped Anchovy	<i>Anchoa hepsetus</i>
Bay Anchovy	<i>Anchoa mitchilli</i>
Lizardfishes	
Largescale Lizardfish	<i>Saurida brasiliensis</i>
Inshore Lizardfish	<i>Synodus foetens</i>
Carps	
Common Carp	<i>Cyprinus carpio</i>
Golden Shiner	<i>Notemigonus crysoleucas</i>
Suckers	
Bigmouth Buffalo	<i>Ictiobus cyprinellus</i>
Freshwater Catfishes	
Blue Catfish	<i>Ictalurus furcatus</i>
Black Bullhead	<i>Ictalurus melas</i>
Yellow Bullhead	<i>Ictalurus natalis</i>
Channel Catfish	<i>Ictalurus punctatus</i>
Sea Catfishes	
Hardhead Catfish	<i>Arius felis</i>
Gafftopsail Catfish	<i>Bagre marinus</i>
Pirate Perches	
Pirate Perch	<i>Aphredoderus sayanus</i>
Toadfishes	

Common Name	Scientific Name
Gulf Toadfish	<i>Opsanus beta</i>
Atlantic Midshipman	<i>Porichthys porosissimus</i>
Clingfishes	
Skilletfish	<i>Gobiesox strumosus</i>
Codfishes	
Southern Hake	<i>Urophycis floridana</i>
Cusk-eels and Brotecelas	
Bearded Brotula	<i>Brotula barbata</i>
Bank Cusk-eel	<i>Ophidion holbrooki</i>
Needlefishes	
Atlantic Needlefish	<i>Strogylura marina</i>
Killifishes	
Diamond Killifish	<i>Adinia xenica</i>
Sheepshead Minnow	<i>Cyprinodon variegatus</i>
Golden Topminnow	<i>Fundulus chrysotus</i>
Gulf Killifish	<i>Fundulus grandis</i>
Saltmarsh Killifish	<i>Fundulus jenkinsi</i>
Starhead Killifish	<i>Fundulus blairae</i>
Bayou Killifish	<i>Fundulus pulvereus</i>
Longnose Killifish	<i>Fundulus similis</i>
Rainwater Killifish	<i>Lucania parva</i>

Common Name	Scientific Name
Livebearers	
Mosquitofish	<i>Gambusia affinis</i>
Least Killifish	<i>Heterandria formosa</i>
Sailfin Molly	<i>Poecilia latipinna</i>
Silversides	
Brook Silversides	<i>Labidesthes sicculus</i>
Rough Silversides	<i>Membras martinica</i>
Inland Silversides	<i>Menidia beryllina</i>
Pipefishes and Seahorses	
Dusky Pipefish	<i>Syngnathus floridae</i>
Chain Pipefish	<i>Syngnathus louisianae</i>
Gulf Pipefish	<i>Syngnathus scovelli</i>
Lined Seahorse	<i>Hippocampus erectus</i>
Temperate Bass	
Striped Bass	<i>Morone saxatilis</i>
White Bass	<i>Morone chrysops</i>
Yellow Bass	<i>Morone mississippiensis</i>
Sunfishes	
Flier	<i>Centrarchus macropterus</i>
Banded Pygmy Sunfish	<i>Elassoma zonatum</i>
Warmouth	<i>Lepomis gulosus</i>

Common Name	Scientific Name
Bluegill	<i>Lepomis macrochirus</i>
Redear Sunfish	<i>Lepomis punctatus</i>
Bantam Sunfish	<i>Lepomis symmetricus</i>
Green Sunfish	<i>Lepomis cyanellus</i>
Largemouth Bass	<i>Micropterus salmoides</i>
White Crappie	<i>Pomoxis annularis</i>
Black Crappie	<i>Pomoxis nigromaculatus</i>
Bluefishes	
Bluefish	<i>Pomatomus saltatrix</i>
Cobias	
Cobia	<i>Rachycentron canadum</i>
Jacks and Pompanos	
Jack Crevalle	<i>Caranx hippos</i>
Atlantic Bumper	<i>Chloroscombrus chrysurus</i>
Bluntnose Jack	<i>Hemicaranx amblyrhynchus</i>
Leather Jack	<i>Oligoplites saurus</i>
Atlantic Moonfish	<i>Selene setapinnis</i>
Lookdown	<i>Selene vomer</i>
Florida Pompano	<i>Trachinotus carolinus</i>
Bigeye Scad	<i>Selar crumenophthalmus</i>

Common Name	Scientific Name
Snappers	
Gray Snapper	<i>Lutianus griseus</i>
Tripletails	
Tripletail	<i>Lobotes surinamensis</i>
Mojarras	
Spotfin Mojarra	<i>Eucinostomus argenteus</i>
Mottled Mojarra	<i>Eucinostomus lefroyi</i>
Grunts	
Pigfish	<i>Orthopristis chrysoptera</i>
Porgies	
Sheepshead	<i>Archosargus probatocephalus</i>
Pinfish	<i>Lagodon rhomboides</i>
Drums	
Freshwater Drum	<i>Aplodinotus grunniens</i>
Silver Perch	<i>Bairdiella chrysoura</i>
Sand Seatrout	<i>Cynoscion arenarius</i>
Spotted Seatrout	<i>Cynoscion nebulosus</i>
Silver Seatrout	<i>Cynoscion nothus</i>
Banded Drum	<i>Larimus fasciatus</i>
Spot	<i>Leiostomus xanthurus</i>
Southern Kingfish	<i>Menticirrhus americanus</i>

Common Name	Scientific Name
Atlantic Croaker	<i>Micropogonias undulatus</i>
Black Drum	<i>Pogonias cromis</i>
Red Drum	<i>Sciaenops ocellatus</i>
Star Drum	<i>Stellifer lanceoatus</i>
Spadefish	
Atlantic Spadefish	<i>Chaetodipterus faber</i>
Mullet	
Striped Mullet	<i>Mugil cephalus</i>
White Mullet	<i>Mugil curema</i>
Barracudas	
Cuaguanche Barracuda	<i>Sphyræna guachancho</i>
Threadfins	
Atlantic Threadfin	<i>Polydactylus octonemus</i>
Stargazers	
Southern Stargazer	<i>Astroscopus y-graecum</i>
Combtooth Blennies	
Striped Blenny	<i>Chasmodes bosquianus</i>
Freckled Blenny	<i>Hypsoblennius ionthas</i>
Sleepers	
Fat Sleeper	<i>Dormitator maculatus</i>
Emerald Sleeper	<i>Erotilis smaragdus</i>

Common Name	Scientific Name
Spinycheek Sleeper	<i>Eleotris pisonis</i>
Gobies	
Lyre Goby	<i>Evorthodus lyricus</i>
Violet Goby	<i>Gobioides broussonetii</i>
Darter Goby	<i>Gobionellus boleosoma</i>
Sharptail Goby	<i>Gobionellus hastatus</i>
Freshwater Goby	<i>Gobionellus shufeldti</i>
Naked Goby	<i>Gobiosoma bosci</i>
Code Goby	<i>Gobiosoma robustum</i>
Clown Goby	<i>Microbius gulosus</i>
Green Goby	<i>Microbius thalassinus</i>
Wormfishes	
Pink Wormfish	<i>Microdesmus longipinnis</i>
Cutlassfishes	
Atlantic Cutlassfish	<i>Trichiurus lepturus</i>
Mackerels and Tunas	
Spanish Mackerel	<i>Scomberomorus maculatus</i>
Butterfishes	
Harvestfish	<i>Peprilus alepidotus</i>
Gulf Butterfish	<i>Peprilus burti</i>

Common Name	Scientific Name
Searobins	
Bighead Searobin	<i>Prionotus tribulus</i>
Lefteye Flounder	
Ocellated Flounder	<i>Ancyclopsetta quadrocellata</i>
Bay Whif	<i>Citharichthys spilopterus</i>
Fringe Flounder	<i>Etropus crossotus</i>
Gulf Flounder	<i>Paralichthys albigutta</i>
Southern Flounder	<i>Paralichthys lethostigma</i>
Soles	
Lined Sole	<i>Achirus lineatus</i>
Hogchoker	<i>Trincetes maculatus</i>
Tonguefishes	
Blackcheek Tonguefish	<i>Symphurus plagiusa</i>
Leatherjackets	
Pygmy Filefishfer	<i>Monacanthus setifer</i>

Appendix D. Threatened and Endangered Species of Cameron Parish, Louisiana

E = Endangered
T = Threatened
C = Candidate
CH = Critical Habitat

Species*	Occurrence	Group	Status
Manatee, West Indian	Possible	Mammal	E
Plover, Piping	Known	Bird	T, CH
Sturgeon, Gulf	Known	Fish	T
Turtle, Green Sea	Known	Reptile	T
Turtle, Hawksbill Sea	Known	Reptile	E
Turtle, Kemp's Ridley Sea	Known	Reptile	E
Turtle, Leatherback Sea	Known	Reptile	E
Turtle, Loggerhead Sea	Known	Reptile	T

*(US Fish and Wildlife Service 2008)

Appendix E. Climate Change Impacts

Anthropogenic climate change is causing increases in global average land and ocean temperatures (Bedoya et al. 2008). This warming trend is likely to cause substantial impacts to amount and timing of precipitation, sea level, species, and ecosystems (U.S. Fish and Wildlife Service 2010a). The southeast United States may be one of the most vulnerable regions in the United States to climate change mainly due to its high biodiversity and long, low-lying coastline (Smith 2004; Karl et al. 2009).

In the Southeast Region the increase in average temperature is expected to continue with the greatest increases occurring in summer. The magnitude of rise is expected to be between 4.5° and 9° Fahrenheit by 2100, along with an increase in frequency of very hot days (Titus et al. 2009; U.S. Congressional Budget Office 2009). The number of freezing days for most of the Southeast Region has declined by four to seven days per year since the mid-1970s (Karl et al. 2009).

Seasonal precipitation is also changing dramatically in this region. Fall precipitation over most of the region is up about 30 percent, with only a small decrease in south Florida (Karl et al. 2009). Summer precipitation has decreased in most areas of the Southeast Region, and during the past three decades there have been several severe droughts. Across the region the proportion of precipitation that falls in high-intensity storms has increased. High intensity storms cause an increased chance of flooding (Karl et al. 2009).

Currently, climate change is not the most important driver of changes in biodiversity; however, it could be the largest driver by the end of the 21st century (Millennium Ecosystem Assessment 2005). Even so, there have already been measurable changes in global biodiversity due to climate change, particularly with regard to changes in species distributions, population sizes, timing of reproduction or migration events, and increases in the frequency of pest and disease outbreaks (Millennium Ecosystem Assessment 2005; Janetos et al. 2008). In the United States, climate change has already impacted terrestrial ecosystems by changing the timing of growing season length, phenology, and species distributions and diversity (Janetos et al. 2008).

As climate change disrupts ecological processes with increasing severity, the Refuge System is likely to experience significant changes in its physical and biological resources. Regional Climate Science Centers are being established by the Department of the Interior. These centers will provide scientific information, tools, and techniques needed to manage land, water, wildlife, and cultural resources in the face of climate change. The USGS and the DOI centers will also work closely with a network of LCCs in which federal, state, tribal, and other managers and scientists will develop conservation, adaptation, and mitigation strategies for dealing with the impacts of climate change (U.S. Fish and Wildlife Service 2010a).

Climate change effects which can be expected on Sabine NWR include increased temperatures, increasing fall precipitation coupled with decreased summer precipitation, increased frequency and severity of droughts, increased intensity of hurricanes with possible increased frequency as well, and rising sea level. Local subsidence will exacerbate the effects of global sea level rise on southern

Louisiana. Management of the refuge will certainly be affected by these changes, though the details are uncertain. Some likely scenarios, however, include the following:

- Increased temperatures and concomitant decreases in severity of cold weather may lead to changes in species composition, including increases in tropical and subtropical exotic invasives such as water hyacinth, giant salvinia, tallowtree, and nutria. Additional management actions may be required to control these species in this case.
- Droughts may increase severity of prescribed fires, and frequency and severity of wildfires, and may lead to more frequent dewatering of marsh habitat. Ground fires, in which organic soil horizons are consumed, may become more frequent.
- If the current bimodal rainfall pattern is enhanced, with higher fall peaks and lower summer troughs, salinity fluctuation in marsh habitat may be wider, leading to changes in plant and animal communities which may or may not be desirable from a management perspective.
- More intense tropical storms will lead to recurring impacts similar to that experienced from Hurricanes Rita and Ike—inundation of freshwater habitats with saltwater, deposition of debris, both of natural and human origin, and damage to refuge infrastructure.
- Rising sea level, combined with local subsidence caused by geologic forces, will lead to increased saltwater intrusion into surface waters and possibly into aquifers. Current salt marsh will convert to open water, while brackish and freshwater marsh habitats will become more saline. Management actions such as construction of levees and terraces may be used to mitigate these effects, but it is unlikely that they will provide a long-term solution.

Appendix F. Oil and Gas Production on Sabine NWR

The following is excerpted from the CCP (U.S. Fish and Wildlife Service 2007):

OIL AND GAS ACTIVITIES

GENERAL INFORMATION

The Service does not hold mineral rights on the majority of the refuge. Subsurface mineral rights were retained by The Texas Company (now Chevron USA, Inc.) in 1937, when Sabine NWR was acquired. The acquisition deed stipulated that oil and gas operations were not to interfere with the refuge purpose, but ultimately stated that the refuge could not prevent the subsurface owner from exercising their rights to access and develop their minerals. A mutually agreed upon special use permit is issued for all oil and gas operations to communicate refuge expectations and environmental concerns to all operating companies. In accordance with current Service policy which is derived from a July 17, 1986, Department of the Interior Solicitor's Office Opinion and Louisiana State mineral rights law, the owners of subsurface oil and gas mineral rights must be granted a reasonable and necessary means of extraction and production.

In more explicit terms, the Solicitor's opinion states that the United States has a number of rights as a surface owner of refuge lands in Louisiana as follows:

1. It may request the mineral owner to alter its proposed operation to accommodate existing and planned uses of the refuge, provided that the burden on the mineral owner is not unreasonable.
2. It may insist that the mineral owner use only the minimum amount of land that is required in order to carry out its operations.
3. The necessary operations that are performed on the refuge must be carried out in a manner which is least injurious to refuge resources.
4. Upon conclusion of each separable phase of operation, the mineral owner must restore the surface to its original condition, insofar as is practicable. This will include filling pits no longer required, leveling land, cleaning up spilled oil and saltwater, reseeding, and repair or replacement of damaged improvements.
5. Access roads damaged by the mineral operator must be put in a condition for use by the United States, although they need not be completely regraded if damage is recurring and unavoidable.

The United States may not:

1. Charge a mineral operator for excavation of dirt on the lease where the dirt is required in order to carry out the operation.

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2. Charge for destruction of timber unless such right was reserved by the United States "grantor."
 3. Interfere with the reasonable and necessary operations of the mineral owner.

Historical Perspectives: Exploration and Production

A total of 107 wells have been drilled on Sabine NWR since its establishment. The refuge currently has 49 plugged and abandoned wells. There are four production facilities, of which only three are active. Over 100 acres are occupied for oil and gas production and support activities.

Exxon-Mobil has recently completed a three-dimensional (3D) seismic survey of 10,560 acres. Hunt Oil Company completed a 14,000-acre 3D seismic program in 2001. In 1998, Sabine NWR had over 90,000 acres covered under a 3D seismic program. Thousands more acres have been surveyed using various techniques on the surface to determine subsurface geological features since about 1945, including gravity meter surveys, seismography, and 2D seismic surveys.

Current Activities: Exploration

Chevron USA, Inc., currently has five companies with leased blocks that occupy portions of the refuge, including: Ballard Exploration Company, Inc., Exxon-Mobil, Hilcorp Energy Company, Petrohawk Resources, Inc., and partner company, Samuel Gary Jr. and Associates. There are 32 producing oil and gas wells, and exploration planning for the next five years has included discussions for at least 10 to 12 new wells. In 2006, one well was drilled and at least two wells worked over.

Current Activities: Production

The East Mud Lake field is a productive field currently operated by Exxon-Mobil. Over the last few years, oil companies have partnered with the Service to accomplish cleanup of fields.

In addition, Chevron USA, Inc., and Hilcorp Energy Company have updated their 20-year-old facilities at the Second Bayou Field to provide more environmentally friendly operations. Modern technology will benefit the refuge, as well as the oil companies.

Mitigation

Eighteen thousand linear feet of planted, earthen terraces were constructed in Units 6 and 7 to mitigate for impacts due to oil and gas activities in 2001. The USACE and the Louisiana DNR require compensatory mitigation for acreage loss due to dredge and fill activities in wetlands. Earthen terraces are designed to be successful mitigation techniques to attenuate waves, reduce marsh erosion, and increase marsh/water interface for use by all estuarine-dependent species. Other possible benefits of earthen terraces that are currently being researched are increased water clarity that may promote the establishment of submerged aquatic vegetation. An unexpected secondary benefit is that they have provided nesting habitat for seabirds such as least terns, forster's terns, and black skimmers. Terrace construction for 2004 allowed the total linear feet in Unit 6 to exceed 60,000.

Chevron USA, Inc., has initiated and addressed a number of remediation projects, but a few areas were improperly restored or left unrestored by other companies.

Contamination Issues

Historically, wells were drilled using open, earthen pits for mud circulation and storage during drilling operations. The drilling mud was oil-based, and the cuttings that were removed from down hole have been known to contain heavy metals, naturally occurring radioactive material, and other forms of contamination. These open earthen pits were left in the late 1980s, but remain on the refuge. Information exists on the locations of these pits and plans for testing are being considered to try and detect if any leaching or other residual impacts have occurred. Chevron USA, Inc., is currently closing old open pits in East Mud Lake Field, ensuring that it complies with Louisiana State Order 298. Plans are to continue to close all remaining pits on the refuge.

Transmission Pipeline Rights-of-Way

Rights-of-way were issued (or were inherited) for transmission lines that traverse the refuge for the purpose of transporting oil, natural gas, synthetic liquid or gaseous fuels, or any refined petroleum-based product. Transmission lines are usually large in diameter and transport product to or from large processing plants. These pipelines do not service mineral production from subsurface minerals, but require a corridor of refuge land for transportation. In contrast, flowlines are usually the smallest in diameter and transport raw product from individual wells, from subsurface mineral production, through the production separation process. Gathering lines, similar to flowlines, usually “gather” the production from multiple wells and transport it to production facilities. Rights-of-way are not issued for flowlines and gathering lines.

Presently, there are nine transmission pipelines (built between 1942 and 1983) that move product from the south to the north of the refuge. These lines do not service producing wells on the refuge. The refuge has more than 40 active flowlines that transport product from privately owned mineral wells to their production facilities, with numerous left buried in place from past production activities. Transmission lines traverse approximately 101 miles of the refuge, while flowlines cover approximately 50 miles.

Existing oil and gas transmission lines and their associated rights-of-way on the Southwest Louisiana National Wildlife Refuge Complex that have been in place for decades have become manageable over the years. Their long-term effects on the environment, which have been identified as creating pathways for saltwater intrusion into freshwater marshes, are being indirectly addressed through numerous wetland management programs and laws such as the Louisiana Coastal Act, the Coastal Louisiana Wetlands Planning Protection and Restoration Act, the North American Wetlands Conservation Act, and many local government and private watershed initiatives such as the Cameron Creole Watershed Management Plan. These laws and initiatives have led to the development of significant wetland restoration projects which have mitigated the effects of some negative impacts associated with oil and gas transmission lines and associated rights-of-way.

Future Management

Existing oil and gas transmission lines on approved Service rights-of-way currently within a national wildlife refuge will be managed as per Service Policy 603 FW 2 in general and explicitly under Section 2.11D, which states:

Existing rights-of-way: We will not make a compatibility determination and will deny any request for maintenance of an existing right-of-way that will affect a unit of the National Wildlife Refuge System unless: (1) The design adopts appropriate measures to avoid resource impacts and includes

provisions to ensure no net loss of habitat quantity and quality; (2) restored or replacement areas identified in the design are afforded permanent protection as part of the national wildlife refuge or wetland management district affected by the maintenance; and (3) all restoration work is completed by the applicant prior to any title transfer or recording of the easement, if applicable. Maintenance of an existing right-of way includes minor expansion or minor realignment to meet safety standards. Examples of minor expansion or minor realignment include: expand the width of a road shoulder to reduce the angle of the slope; expand the area for viewing on-coming traffic at an intersection; and realigning a curved section of a road to reduce the amount of curve in a road.

New construction for oil and gas transmission line rights-of-way will not be permitted, because they can significantly contribute to further land loss on coastal Louisiana national wildlife refuges. Canals built for the construction and repair of oil and gas transmission lines allow saltwater to penetrate further inland, particularly during droughts and storms, which can have severe effects on wetlands (Wang 1987). This is evident for the oil and gas transmission line rights-of-way which were established in accordance with the Federal Department of Transportation and Louisiana Department of Transportation regulations already established on Sabine NWR. Oil and gas transmission lines constructed since the 1940s are still readily apparent. Compaction and displacement of hydric soils during oil and gas transmission line repair and/or construction reduces water exchange and can result in increased waterlogging and plant mortality (Swenson and Turner 1987). Excavation necessary for oil and gas transmission line construction causes significant hydrological changes. Exposing hydric soil to oxygen changes the natural ecological processes, including chemical transformations, sediment transport, vegetation health, and migration of organisms. Furthermore, by altering salinity gradients and patterns of water flow, the natural process by which coastal marshes are replenished and protected cannot occur (Reed and Wilson 2004).

Restoration of Coastal Marsh

Restoration of coastal marsh is a priority on national wildlife refuges in the Louisiana coastal zone. Approximately \$10 million has been spent on the Southwest Louisiana National Wildlife Refuge Complex trying to restore marsh. Extensive changes and alterations due to new pipeline rights-of-way could negatively affect restoration project predictability and life span. The stability created through these restoration projects could be jeopardized when major hydrologic changes occur due to new pipeline construction. Therefore, managing existing pipelines and rights-of-way in accordance with current Service policy, and state and federal law is permissible under current conditions. Any expansion beyond the current conditions would be an inappropriate use in conflict with the purposes for which the refuge was established, considering the current status of Louisiana's coastal wetlands and the Service's role in managing and protecting this state's coastal resources.

WILDFIRES

Lightning strikes and seismic survey activity are the primary causes of wildfires on the refuge. In recent years drought or dry conditions have disrupted the normally scheduled prescribed burning regime. The Southwest Louisiana NWR Complex's fire team has to spend more time fighting unwanted wildland fires on the refuge and is frequently called upon to fight wildfires in other states. The application of prescribed fire has decreased due to the fire team's increased workload and unsuitable dry weather conditions.

The following State of Louisiana regulations will be adhered to when granting pipeline rights-of-way on Sabine NWR. Rights-of-way width on Sabine NWR will be no more than 25 feet.

STATE OF LOUISIANA
GRANTING OF RIGHTS-OF-WAY
TO
CORPORATIONS
OR
INDIVIDUALS

(As defined in R.S. 41:1173-1174 and provided
for by R.S. 36:1 and 36:4 et seq.)
July 1, 1990

DIVISION OF ADMINISTRATION
State Land Office
P.O. Box 44124, Capitol Station
Baton Rouge, Louisiana 70804

RS 41:1173. Granting of rights-of-way to corporations or individuals.

The Governor and the Commissioner of Administration may grant rights-of-way across and through any public lands belonging to the State of Louisiana—to any individual or corporation doing business in this State—provided that adequate consideration is paid the state by the Grantee of the right. (Source: Act 1916, No. 215 1.)

RS 41:1174. Disputed title; deposit of consideration in escrow.

Should the Governor and the Commissioner of Administration grant rights-of-way across and through any public lands, the title to which is in dispute, they may provide that the consideration to be paid the State by the Grantee of the right shall be deposited in escrow with the Commissioner of Administration, to be held by that officer pending the final determination of the validity of the title to the land or until the Governor and the Commissioner of Administration and the Grantee otherwise agree the payment should be made or released as provided for in the agreement. Added Act 1964, No. 291.

The following rules and regulations concerning the granting of rights-of-way have been adopted by the Commissioner of Administration:

1. Applicants are to use the State Right-of-Way form provided by the Division of Administration. A special form is used for escrow agreement permits.
2. The Right-of-Way form must be submitted in triplicate with a legal size plat(s) attached to each copy.

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3. The description contained in the Right-of-Way form must indicate section, township and range, or area and block number(s) if offshore; name of the body of water to be crossed; the size of the pipe and the length of the right-of-way in rods.
 4. The plat(s) must reveal the following:
 - a. Station numbers at the mean low water elevation on a river, the station numbers at the mean high water elevation on a lake bay or Gulf of Mexico; or station numbers at ingress and egress of State properties. Said plat, when illustrating the mean low water line of a river or the mean high water line of a lake or the Gulf, will be authoritative only as to the date of the application for calculation of the State's consideration. The limits of State property reflected on said plat are illustrative only and recognized solely and only for computing the fee for this grant, and are not intended and shall not be construed as determinative of actual title for the benefit of any adjoining owners, whether a Grantee herein or a third party.
 - b. The section, township and range if in an area that has been surveyed.
 - c. The product to be transported.
 - d. The location of the pipeline with respect to the right-of-way.
 5. Names of adjoining landowners cannot be shown on the plat unless necessary for legal description.
 6. The Right-of-Way form must be accompanied by a letter of intent which shall contain the following information:
 - a. Initiating and terminating point of the pipeline.
 - b. Point of origination of product to be transported as a result of this construction.
 - c. Capacity or if a loopline added capacity as a result of this construction.
 - d. Estimated volume of product to be transported as a result of this construction.
 - e. A detail of construction.
 - f. Pipe specifications including size, wall thickness and type.
 - g. The proposed and maximum operating pressures.
 7. Where State mineral leases are traversed, an applicant will furnish the Commissioner of Administration a copy of the letter of notification (with signed, certified returned receipt attached), which has been sent to the mineral lessees.
 8. It is necessary that permission or clearance be obtained from the United States Corps of Engineers; State Office of Public Works, Department of Transportation and Development; Louisiana Department of Environmental Quality, Water Pollution Control Division; The Louisiana Department of Wildlife and Fisheries and both the Coastal Management Division and the Office

of Conservation of the Department of Natural Resources if the operation is within their respective jurisdictions and from any other agency having permit authority over the proposed project.

9. Clearance shall be obtained from the Secretary of the Department of Wildlife and Fisheries when oyster leases are to be traversed.
10. Written consent must be obtained from the Secretary of the Department of Wildlife and Fisheries if the proposed right-of way crosses a State or Federal preserve. Similar clearance is required from any agency having jurisdiction over surface rights of state lands being crossed.
11. The State requires payment for all grants across State lands or navigable streams—regardless of size.
12. The proposed route of the pipeline shall be subject to approval of the Commissioner of Administration.
13. Fees for permits shall be as follows:
 - Class 1. Pipe 2 inches up to 19 inches outside diameter with a maximum of 75 feet right-of-way during construction to revert to 35 feet after construction is completed with the additional right of ingress and egress for the purpose of maintenance, repairs, removal or modification— \$25.00 per rod.
 - Class 2. Pipe 19 inches up to 36 inches outside diameter with a maximum of 100 feet right-of-way during construction to revert to 50 feet after construction is completed with the additional right of ingress and egress for the purpose of maintenance, repairs, removal or modification— \$35.00 per rod.
 - Class 3. Pipe over 36 inches outside diameter with a maximum of 200 feet right-of-way during construction to revert to 60 feet after construction is completed with the additional right of ingress and egress for the purpose of maintenance, repairs, removal or modification— \$45.00 per rod. The minimum fee for any application processed shall be \$50.00 with a \$100.00 fee assessed for any assignment of permit thereafter.
14. Contract term—20 years with option to renew for additional 20 year term. The option to renew shall be on the same terms and conditions as the original agreement except that the consideration shall be adjusted to reflect the percentage of increase or decrease in the cost of living index as established by the Consumer Price Index for Urban Wage Earners and Clerical Workers published by the Bureau of Labor Statistics of the United States Department of Labor or any revision or equivalent of any such index published by the United States Government, which has occurred from date of this instrument to the date of renewal provided, however, that in no event shall consideration of such renewal be less than the consideration paid herein for the original term.
15. There shall be no above-ground installations, i.e., valve setting, tie-overs, platforms, etc., without the express consent and approval of the Commissioner of Administration. The Commissioner shall have authority to establish the basis of compensation (which amount shall be in addition to the per-rod consideration referred to in these rules) for such aboveground installation. The application for pipeline rights-of-way shall contain a concise description of any such above-ground facility together with appropriate drawing, showing location of same and profile of design and style.

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16. All pipelines constructed under permits granted by the State of Louisiana shall be in accordance with Parts 191, 192 and/or 195 of Title 49 of the Code of Federal Regulations, as amended and other Federal and State Laws not in conflict therewith.
 17. The State of Louisiana is held free from any and all liabilities.
 18. A copy of the Right-Of-Way Grant, along with a pertinent plat(s) attached, must be filed with the Clerk of Court of the Parish or Parishes affected and the Division of Administration furnished recordation data.

Appendix G. Fish and Wildlife Service Environmental Action Statement for Categorical Exclusion

Within the spirit and intent of the Council on Environmental Quality's regulations for implementing the National Environmental Policy Act (NEPA), and other statutes, orders, and policies that protect fish and wildlife resources, I have established the following administrative record and determined that the following proposed action is categorically excluded from NEPA documentation requirements consistent with 40 CFR 1508.4, 516 DM 2.3A, 516 DM 2 Appendix 1, and 516 DM 6 Appendix 1.4.

Proposed Action and Alternatives. The proposed action is the approval and implementation of the HMP for Sabine NWR. This HMP is a step-down management plan providing the refuge manager with specific guidance for implementing goals, objectives, and strategies identified in the Sabine NWR CCP (U.S. Fish and Wildlife Service 2007).

The preferred CCP action was the proposed alternative among three alternatives considered in the Environmental Assessment (EA) (Draft CCP and EA 2007). In the CCP, the preferred action (Alternative B) is to "continue to keep the refuge operational with minimal public use programs functional, but at a reduced cost (near term), and increase marsh restoration, enhance fish and wildlife management, and expand public use (long term)." Under the preferred action "Sabine NWR will increase marsh restoration and enhance wildlife management, stepping up these efforts from current levels. A habitat improvement feasibility study will be performed for Unit 3. The refuge will improve marsh plant communities and shallow water, increase waterfowl food production, and provide habitat and sanctuary needs for migrating, wintering, breeding ducks (mottled ducks), and geese and other birds, and fish and wildlife. It will also protect and/or restore 43,200 acres of intermediate and brackish marsh and continue working toward restoring emergent marsh. The beneficial use of dredge material for marsh restoration will be continued. Sabine NWR will closely monitor oil and gas activities to minimize impacts to wetland habitats and wildlife usage. It will also increase surface reclamation at former petroleum extraction sites to improve habitat for wintering migratory birds and other species. All new non-refuge mineral owners' requests for petrochemical transmission infrastructure will be prohibited."

"Like Alternative A, Alternative B will maintain salinity monitoring throughout the refuge at established discrete salinity stations. Improving water quality will be a major thrust for the refuge. Fire management objectives under Alternative B will be the same as Alternative A: Sabine NWR will continue to use fire as a multipurpose management tool for reducing hazardous fuels, promoting habitat diversity, and prescribed burning of approximately 20,000 acres per year. Cultural resources will continue to be protected."

The CCP has defined goals, objectives, and strategies to achieve the stated action. The actions (strategy prescriptions) further detailed in this HMP have been identified, addressed, and authorized by the Sabine NWR CCP. These include:

Impounded Marsh Management Strategies:

- Opportunistically utilize natural freshwater pulses to flood impounded units (1A, 1B, and 3) by manipulating the new CS-23 WCS in response to periods of high freshwater flow, while

maintaining connectivity with the marine environment during crucial migration periods for larval shrimp and fish (details in Water Management Plan).

- In conjunction with drought periods, but no more frequently than 3 years on any given site, draw down water levels and allow marsh to dry out, and apply prescribed fire as needed to reduce accumulation of organic matter, set back undesirable native and/or exotic plants, and increase areas of open water to maintain rough equality between emergent vegetation cover and open water. Fire should be applied during the fall and should be conducted under conditions which ensure that fuel (i.e., organic soil) consumption will be patchy.

Operation of the CS-23 water control structures will be regulated by the new Water Management Plan. Important elements of this plan include:

- WCS do not completely regulate flow; marsh is still open to unregulated flow at several locations.
- Normal operation of WCS will allow unimpeded flow of water.
- During periods of high saltwater intrusion potential, based on salinity monitoring data, flow can be restricted or halted through the three WCS.
- WCS will be opened during critical periods of ingress and egress for brown shrimp, white shrimp, and red drum.
- When a tropical storm surge is expected, the WCS will be closed to exclude the surge. (When predicted storm surge is greater than 3 feet, WCS will be left open to prevent damage to the structures and/or erosion of the levees surrounding the WCS. This procedure will be especially important in the event that a personnel evacuation is ordered in advance of the storm, leaving the WCS unstaffed.)

Unimpounded Marsh Management Strategies:

- Operate the WCS at Hog Island Gully, West Cove, and Headquarters in accordance with the Water Management Plan to control salinity in Units 1, 2, and 4, and to maintain elevated water levels in those units throughout the year, with an emphasis on moon cycles. WCS will be opened at specified times, dimensions, and intervals between MAR 01-APR 15, MAY 15-JUN 14, JUN 15-JUL 31, opening date of white shrimp season-NOV 30 and later periods as dictated by weather, and SEP 01-SEP 30 to allow for ingress and egress of brown shrimp, white shrimp, and red drum.
- Terraces will continue to be constructed in open water areas in Units 5, 6, and 7 to prevent and reverse marsh loss through saltwater intrusion, wave action, and storm surge, as funding becomes available.
- Prescribed fire will be applied to unimpounded marsh during dry periods on an average 3-year return interval as needed to maintain 35 - 45 percent emergent vegetation and 55 -65 percent open water. Fire will be applied under conditions which will result in patchy burns to avoid excessive removal of organic soils.

Undesirable Flora Strategies:

- Periodic drawdowns and application of herbicides and fire will be used as tools to control invasive plants including tallowtree, chinaberry, saltcedar on levees, and giant salvinia and water hyacinth in open water areas. Exotic woody vegetation on levees will be treated with fire, approved herbicides, and/or mowing as needed to prevent them from exceeding 10 percent cover.
- Prescribed fire will be applied to marsh and levees as needed on at least 20,000 acres per year to set back woody vegetation and unwanted herbaceous vegetation, including exotic and native species. Growing season burns will be utilized for controlling woody vegetation whenever feasible, because of their greater potential for causing root-kill of woody plants.

Undesirable Fauna Strategies:

- When resource damage caused by feral swine becomes apparent, hogs will be removed (trapped and/or killed) by commercial contractors.
- When the density of nutria reaches the point where observable resource damage is occurring (i.e., eatouts, damage to levees), commercial trappers will be contracted to remove them.

Prescribed Fire Strategies:

- A total of at least 20,000 acres per year will be treated with prescribed fire. Wildfires will be treated in accordance with the Fire Management Plan and may be used to achieve habitat management goals (wildland fire use) (U.S. Fish and Wildlife Service 2011).
- Prescribed fire will be used on levees and other lands to manage woody vegetation and reduce the cover of exotic woody plants such as tallowtree. Burns will be conducted during the growing season when feasible to increase root-kill on woody plants. Known or future designated rookery sites will not be burned.
- Prescribed fire will be used during the dry season of dry years (late summer/early fall), no more frequently than every 3 years, to reduce peat accumulations in impounded units when emergent marsh vegetation becomes denser than target levels and open water falls below desired percent (i.e., 40 percent). This treatment will also have the objectives of reducing accumulations of fuel and of opening up space for higher plant diversity in areas where roseau cane, maidencane, or cattails have created monocultures.
- Prescribed fire will be used in unimpounded marsh units with an approximately 3-year fire return interval to remove excess fuel, increase vegetative diversity, maintain optimum mix of open water and emergent marsh vegetation, set back undesirable/exotic invasive plants, and maintain the health and diversity of coastal prairie patches.

Categorical Exclusion(s). Categorical Exclusion Department Manual 516 DM 6, Appendix 1 Section 1.4 B (10), which states “the issuance of new or revised site, unit, or activity-specific management plans for public use, land use, or other management activities when only minor changes are planned. Examples could include an amended public use plan or fire management plan” is applicable to implementation of the proposed action.

Consistent with Categorical Exclusion (516 DM 6, Appendix 1 Section 1.4 B (10)) this HMP is a step-down management plan which provides guidance for implementation of the general goals, objectives, and strategies established in the CCP, serving to further refine those components of the CPP specific to habitat management. This HMP does not trigger an Exception to the Categorical Exclusions listed in 516 DM 2, Appendix 2.

Minor changes or refinements to the CCP in this activity-specific management plan include:

- Habitat management objectives are further refined by providing numerical parameter values that more clearly define the originating objective statement.
- Habitat management objectives are restated so as to combine appropriate objectives or to split complicated objectives for improved clarity in the context of this HMP.
- Specific habitat management guidance, strategies, and implementation schedules to meet the CCP goals and objectives are included (e.g., location, timing, frequency, and intensity of application).
- All details are consistent with the CCP, except the following items, and serve to provide the further detail necessary to guide the refuge in application of the intended strategies for the purpose of meeting the habitat objectives.
- Two strategies have been deleted from the CCP as a result of the planning process that produced this HMP. In accordance with Conservation Planning and Policy Guidance DCPG No. 2 – Guidance for Revising Comprehensive Conservation Plans, these deletions constitute a Minor CCP Revision, and compliance with the National Environmental Policy Act is hereby achieved. The existing CCP will remain in effect for the remainder of its planning period, with the following minor revisions properly annotated.
 - The Project Leader has determined that Strategy (c) under Objective A-2 in the CCP, which reads “Replace 5 water control structures at Units 1A, 1B, and 3,” is unnecessary and would be counterproductive for achieving the refuge purpose. The structures are currently functional, but their utility has been superseded by the completion of the three, CS-23 water control structures along Louisiana Highway 27. This strategy is therefore deleted from the CCP. No changes to CCP goals or objectives result from this change.
 - The Project Leader has determined that Strategy (b) under Objective B-8 in the CCP, which reads “Develop a project to dredge and maintain canals” would be counterproductive to the overall habitat and fish and wildlife management goals set forth in the CCP. This strategy is therefore deleted from the CCP. No changes to CCP goals or objectives result from this change.

Permits/Approvals. Endangered Species Act, Intra-Service Section 7 Consultation was conducted during the CCP process. The result was a determination that implementation of the proposed action would have no effect on bald eagle, American alligator, Kemp’s ridley sea turtle, loggerhead turtle, or wood stork.

Other items to include that should be listed and that can be found in the FONSI, EAS, and Administrative Record of the Final CCP:

- Executive Orders 11988/11990 – May 31, 2006
- Floodplain Management and Protection of Wetlands, May 31, 2006
- Form DI-711, Intergovernmental Notice of Proposed Action, March 29, 2006
- Fish and Wildlife Service Policy 603 FW 2, Section 2.11D, Oil and Gas Activities
- National Historic Preservation Act, Protection of Cultural Resources, March 29, 2006

Public Involvement/Interagency Coordination. This HMP is a step-down of the approved CCP for Sabine NWR. The development and approval of the CCP included appropriate NEPA documentation and public involvement. An Environmental Assessment was developed (Draft CCP/EA 2007) which proposed and addressed management alternatives and environmental consequences. Public involvement included public notification and public meetings held in 2002 as follows: October 1, Carlyss, LA; October 8, Grand Lake, LA; October 10, Cameron, LA; October 16, Hackberry, LA; and October 17, Johnson Bayou, LA. Approximately 25 people in total attended these meetings. In addition, public open-house meetings were held in Lake Charles, LA, on January 16 and February 4, 2003, which were attended by a total of 33 people. Additionally, a public meeting was held in conjunction with the public comment period for the Draft CCP/EA on July 11, 2007, in Lake Charles, LA. A total of 16 people, including staff members for elected officials, attended this meeting.


Supporting Documents. Supporting documents for this determination include relevant office file material and the following key references:

USFWS 2007. Sabine National Wildlife Refuge Comprehensive Conservation Plan.

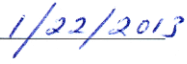
USFWS 2007. Sabine National Wildlife Refuge Draft Comprehensive Conservation Plan and Environmental Assessment.

Fire Management Plan, Sabine National Wildlife Refuge, Louisiana 2011. Copy on file at Southwest Louisiana National Wildlife Refuge Complex office.

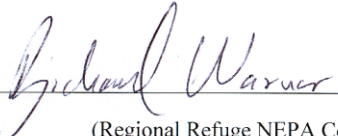
Operation, Maintenance and Rehabilitation Plan for Sabine National Wildlife Refuge Structure Replacement Project CS-23. 2004. Copy on file at Southwest Louisiana National Wildlife Refuge Complex office.



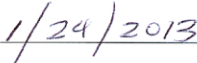
(Project Leader)



(date)



(Regional Refuge NEPA Coordinator)



(date)

SABINE NATIONAL WILDLIFE REFUGE

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